WASHINGTON STATE

CONSERVATION COMMISSION

SALMON

HABITAT LIMITING FACTORS

FINAL REPORT

WATER RESOURCE INVENTORY AREA

13

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EXECUTIVE SUMMARY

Section 10 of Engrossed Substitute House Bill 2496 (Salmon Recovery Act of 1998), directs the Washington State Conservation Commission, in consultation with local government and treaty tribes to invite private, federal, state, tribal, and local government personnel with appropriate expertise to convene as a Technical Advisory Group (TAG). The purpose of the TAG is to identify limiting factors for salmonids. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon, including all species of the family Salmonidae." The bill further clarifies the definition by stating "These factors are primarily fish passage barriers and degraded estuarine areas, riparian corridors, stream channels, and wetlands."

The intent of the legislation and watershed restoration is to provide healthy, productive runs of salmon that will support sport, commercial, and tribal fisheries, and for future generations. This will require management to a higher standard than just minimum viable habitat. Although there remains some debate on specific habitat thresholds necessary for productive salmon habitat, there is broad consensus that salmon require:

- cool, clean, well-oxygenated water,
- instream flows that mimic the natural hydrology of the watershed, maintaining adequate flows during low flow periods and minimizing the frequency and magnitude of peak flows (stormwater),
- clean spawning gravels not clogged with fine sediment or toxic materials,
- presence of instream pools that will support juvenile rearing and resting areas for returning adults,
- abundance of instream large woody debris, particularly large key pieces, that provide cover, create pools, and provide habitat diversity,
- free, unobstructed migration for juveniles and adults to and from the stream of origin,
- broad, dense riparian stands of mature conifer that provides cover, shade, LWD recruitment, etc., and
- estuarine conditions that support production of prey organisms for juvenile outmigrants as well as for rearing and returning adults.

A discussion of the role of healthy habitat is included in Appendix 1.

The following report has been prepared in accordance with the above instructions for Water Resource Inventory Area 13 – Deschutes (Figure 1). It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis. This report is based on a combination of existing watershed studies and knowledge of the TAG participants. A full habitat limiting factors analysis would require extensive new scientific studies for each of the subwatersheds in WRIA 13. The hatchery, hydro, and harvest segments important to a full limiting factors analysis will be dealt with in other forums.

Habitat limiting factors are presented in separate chapters:

- by habitat factor type, to identify the magnitude of a specific factor across the streams in the WRIA, and
- by individual watershed, to identify the scope of limiting factors within each specific watershed.
- Table 1 summarizes the scope of specific known habitat limiting factors in WRIA 13, and which factors are applicable to any particular stream or watershed.

Data included in this report include formal habitat inventories or studies specifically directed at evaluating fish habitat, other watershed data not specifically associated with fish habitat evaluation, and personal experience and observations of the watershed experts involved in the TAG. Watershed studies were limited within the WRIA, particularly studies specifically directed at evaluating fish habitat. Although the data were scattered, and the specific habitat concerns differed between streams, there are some common habitat themes, including:

- natural stream ecological processes have been significantly altered due to adjacent land management practices and direct actions within the stream corridor,
- fine sediment (<.85 mm) levels in the stream gravels regularly exceed the <12% level identified as representing suitable spawning habitat,
- lack of adequate large woody debris in streams, particularly larger key pieces that are critical to developing pools, log jams, and other habitat components important to salmonids,
- lack of adequate pool frequency and large, deep pools that are important to rearing juvenile salmonids and adult salmonids on their upstream migration,
- naturally high rates of channel in this geologically young basin, but further exacerbated rate of steambank erosion and substrate instability due to loss of streambank and riparian integrity, and alteration of natural hydrology,
- loss of riparian function due to removal/alteration of natural riparian vegetation, which affects water quality, lateral erosion, streambank stability, instream habitat conditions, etc.,
- the presence of a significant number of culverts/screens/dams/etc. that preclude unrestricted upstream or downstream access to juvenile and adult salmonids,
- significant alterations to the natural stream hydrology in streams where the uplands have been heavily developed, and the threat of similar impacts to streams that are experiencing current and future development growth, and
- estuarine/marine function is significantly impacted by physical alteration of the natural estuary, by poor water quality in the estuary, and by significant alteration of nearshore ecological function due to shoreline armoring.

Few, if any, of the habitat data/observations meet the highest standard of peer review literature, but should nevertheless be considered as valid, as they are based on the experience of the watershed experts that are actively working in these streams. There are a number of data gaps, which will require additional specific watershed research or evaluation.

Protection/restoration of salmonid resources can not be accomplished by watershed restoration projects alone. It is unlikely that we will be able to get ourselves out of this salmon predicament using the same land management approaches that got us into it. We will need to look at the watershed with a clear new vision. Salmonid recovery will require a combination of efforts, including:

- revision, implementation, and enforcement of land use ordinances that provide protection for natural ecological processes in the marine, instream, and riparian corridors, including measures to maintain effective impervious surfaces to levels, and in a manner, that will maintain natural hydrology,
- protection of marine, instream, and riparian habitat that is currently functioning, particularly key habitat areas, and
- restoration of natural marine, instream, and riparian ecological processes where they have been impaired.

In addition, the status of chinook in Woodland, Percival/Black Lake Ditch, and McLane creeks should be reviewed to determine whether these are the result of self perpetuating spawners, or whether chinook returns are strictly the result of Deschutes River hatchery strays.

Table 1: Identified habitat limiting factors for freshwater streams and marine areas of WRIA 13

STREAM NAME	**WRIA INDEX**	Fish Passage	Floodplain Connectivity	Bank Stability	LWD	Pools	Side Channel Habitat	Substrate Fines	Riparian	Water Quality	Water Quantity	Biological Processes	Lakes	Estuarine
Unnamed	13.0001													
Dobbs Creek	13.0005									X	X			
Woodland Creek	13.0006	X		X	X			X	X	X	X			
"Fox Hollow Cr."	13.0007													
Jorgenson Cr.	13.0008	X						X						
Fox Cr.	13.0009	X												
Eagle Creek	13.0010	X		X				X						
Woodard Creek	13.0012	X			X				X	X	X			
Sleepy Creek	13.0015									X				
Adams Creek	13.0018	X								X				
Unnamed	13.0021	X								X				
Ellis Creek	13.0022	X						X		X				
Mission Creek	13.0025									X				
Indian Cr.	13.0026	X						X		X				
Moxlie Cr.	13.0027	X						X		X				
Percival Creek	13.0029	X		X	X	X		X	X	X	X		X	X
Black Lake Ditch	13.0030	X		X	X	X		X	X	X	X		X	X
Deschutes River	13.0028			X	X	X	X	X	X	X	X		X	X
Unnamed	13.0032													
Chambers Cr.	13.0033							X	X	X	X			
Unnamed	13.0034							X	X	X	X			
Unnamed	13.0036									X				
Spurgeon Cr.	13.0037									X				
Offut Lake Outlet	13.0040	X												
Silver Springs	13.0041													
Unnamed	13.0042													
Unnamed	13.0045	X												

STREAM NAME	WRIA INDEX	Fish Passage	Floodplain Connectivity	Bank Stability	LWD	Pools	Side Channel Habitat	Substrate Fines	Riparian	Water Quality	Water Quantity	Biological Processes	Lakes	Estuarine
Reichel Cr.	13.0046										X			
Unnamed	13.0047	X												
Pipeline Cr.	13.0051													
Unnamed	13.0052													
Hull Cr.	13.0053													
Fall Cr.	13.0057			X										
Unnamed	13.0066													
Mitchell Cr.	13.0069			X	X									
Huckleberry Cr.	13.0086			X	X			X	X					
Johnson Cr.	13.0089			X	X			X						
Thurston Cr.	13.0095			X	X									
Unnamed	13.0097			X	X									
Unnamed	13.0102													
Unnamed	13.0104						X							
Schneider Cr.	13.0131									X				
Green Cove Creek	13.0133				X	X			X					
Unnamed	13.0135													
Houston Creek	13.0137	X												
McLane Creek	13.0138				X	X		X	X					
Swift Cr.	13.0139	X			X	X		X	X					
Perkins Creek	13.0140	X												
Cedar Flats Cr.	13.0141													
Unnamed	13.0142													
Beatty Cr.	13.0143	X												
Henderson Inlet	13.MAR									X				X
Budd Inlet	13.MAR									X				X
Eld Inlet	13.MAR									X				X

NOTE: Absence of "X" indicator is typically a result of lack of applicable studies or data, rather than an affirmative indication that the concern is not applicable to a particular stream.

WATERSHED DESCRIPTION

General Description

Located at the southern end of Puget Sound (Figure 1), Water Resource Inventory Area (WRIA) 13 is almost entirely within the bounds of Thurston County, with a small portion (the headwaters of the Deschutes River) in Lewis County. The drainages of the WRIA empty into three saltwater inlets that, in turn, define the major watersheds: Henderson Inlet to the East, centrally located Budd Inlet, and Eld Inlet to the West. The Deschutes River is the major hydrologic basin in WRIA 13, with a number of other smaller independent tributaries to salt water.

The geology of WRIA 13 is fairly uniform throughout the drainages. Glacial ice scoured the Puget Sound lowlands at least four times, retreating most recently only 10,000-12,000 years ago. The main glacial advances of the Salmon Springs and the later Vashon glaciations were most important to the area. Each time the massive glaciers advanced, they dammed the outlet of Puget Sound and created a vast lake that drained south into the Black River valley. “Rock flour,” the finely ground remains of rocks pulverized by glacier action, settled on the bottom of this glacial lake. These deposits became the commonplace blue clays of the Puget lowlands. The great weight of the glaciers compacted underlying sediments into a concrete-like material called “glacial till” (unsorted sand, gravel, and boulders in a silt and clay matrix, a.k.a. hardpan). As the glaciers melted, the runoff deposited thick layers of sand and gravel known as “outwash” (moderately to well sorted sands and gravels). Each of these glacially deposited materials—clay, till and outwash—is present in the basins in various combinations. Outwash provides the formations that hold groundwater, and all three provide the parent material for most soils.

The climate of the region is typical Northwest maritime. Summers are relatively dry and cool while winters are mild, wet and cloudy. Annual precipitation averages about 51 inches in Olympia to over 90 inches in the upper watershed (Puget Sound Cooperative River Basin Team 1990). During the wet season, rainfall is usually of light to moderate intensity and continuous over a period of time, rather than heavy and brief. The prevailing winds blow from the southwest and have a mean speed of 6.5 miles per hour. The average frost-free period is 150 to 200 days. The average annual snowfall, usually 10-15 inches, occurs generally between November and April (National Weather Service).

Henderson Inlet Watershed

The Henderson Inlet watershed lies in the northeast section of WRIA 13 and has a total drainage area of about 29,275 acres (Thurston County 1989). The topography of the watershed is divided into three parts: the Dickerson Point peninsula, the Johnson Point peninsula, and the Woodland Creek Basin. The three areas drain surface water into Henderson Inlet. Most of the basin lies at an elevation of less than 200 feet above sea level. The inlet is about five miles long from Dickerson Point to the mouth of Woodland Creek, ranging from .25 to .75 miles wide, and covering 2.5 square miles in area. It has an average depth of 25 feet, and reaches its maximum depth of 60 feet near the mouth (Thurston County et al. 1995). The southern head of the inlet forms an estuary at the mouth of Woodland Creek and reveals large mudflats at low tide.

Dickerson Point peninsula, which forms the western boundary of the watershed, is approximately 5 miles long and varies in width from 2.5 to 3 miles. The width of the beaches and the height of the bluffs vary depending upon the extent of wave-cut erosion. Most of the bluffs rise steeply

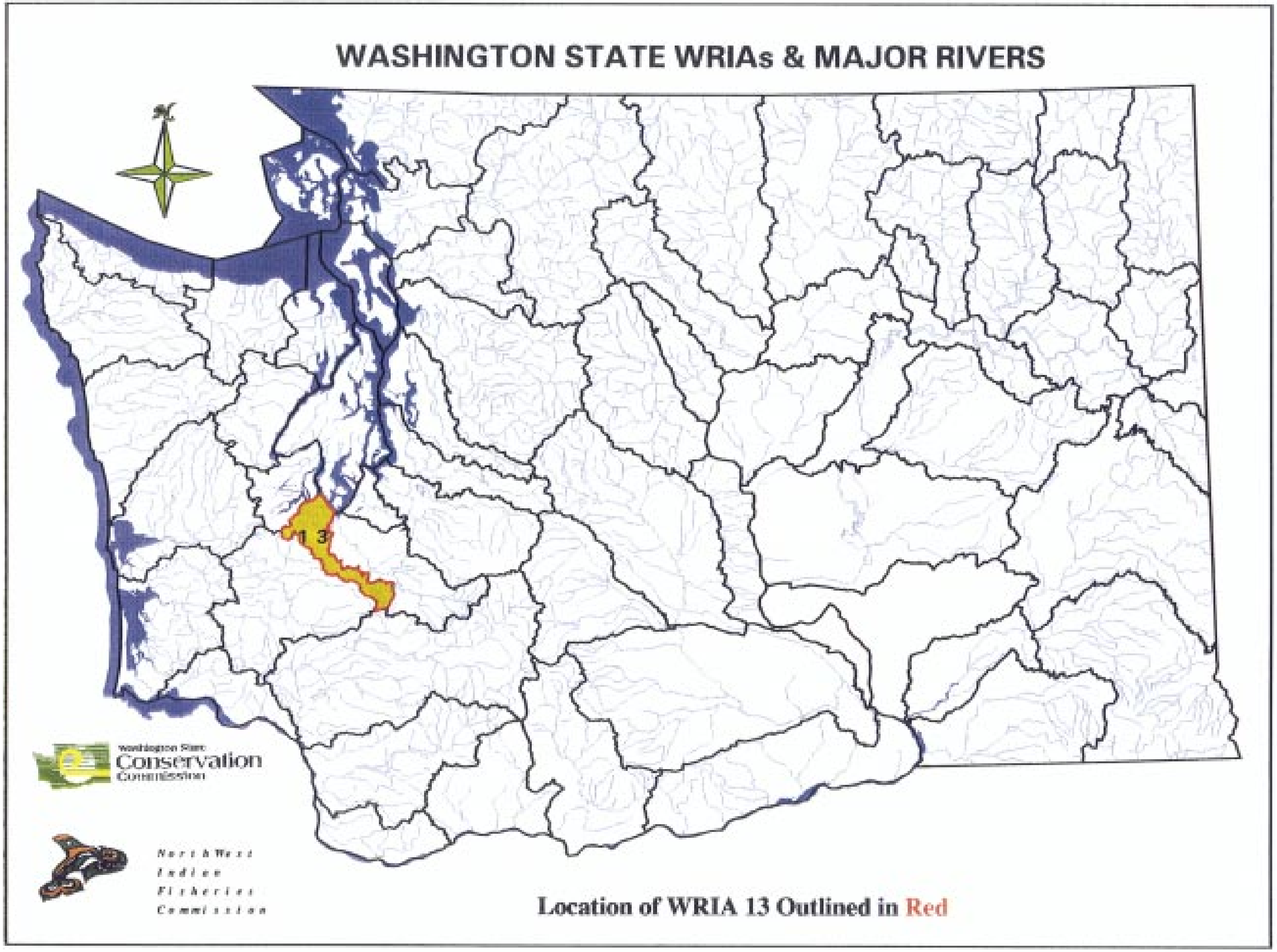

Figure 1: Location of WRIA 13 at the southern end of Puget Sound

from the beaches reaching a height between 5 and 100 feet. The slopes are bisected by steep, narrow ravines with intermittent streams that drain into the many small coves along the shoreline. The largest stream on Dickerson Point peninsula is Woodard Creek, which flows northward out of a 45-acre wetland at an elevation of 150 feet above sea level to Woodard Bay midway up the peninsula. Woodard Creek is about 7.5 miles long. The highest point of the peninsula is 177 feet, just southeast of Woodard Bay (Thurston County 1989).
Woodland Creek basin begins in the north central region of Thurston County. It flows north for 11 miles from its headwaters at Hicks Lake through a series of other lakes (Pattison [Patterson], Long, and Lois Lakes) to its terminus at the southernmost point of Henderson Inlet. The drainage of the lakes is slow, and the areas between them are peat bogs, marshes, and beaver ponds. The high point of the basin is 270 feet, south of Pattison Lake.

Johnson Point peninsula delineates the eastern boundary of the Henderson Inlet watershed. It is 6 miles long and varies in width from 2.5 miles in the north, to 4.5 to 5 miles in the south. The topography of the peninsula is similar to that of Dickerson Point. The high point of the peninsula, 307 feet, creates the eastern watershed boundary.

Woodland and Woodard Creeks are the largest of the major tributaries to Henderson Inlet and drain about 80% of the watershed. The other streams in the watershed, Dobbs Creek, Meyer Creek and Sleepy Creek, drain small areas of the Dickerson Point and Johnson Point peninsulas to the north of Woodard Creek and Woodland Creek basin.

The Henderson Inlet watershed includes rural, unincorporated areas as well as the heart of the city of Lacey and portions of the city of Olympia. As of 1988, the population and dwelling units within the watershed numbered 38,066 and 15,015 respectively. Between 1979 and 1989, over 41% of the new housing in Thurston County was built in the Henderson Inlet watershed. Growth by the year 2010 is projected to total 61,018 people and 24,847 dwelling units (Thurston County 1989). Estimates for various land uses in the Henderson Inlet watershed are identified in Table 2.

Table 2: Land use in the Henderson Inlet watershed (Source, Thurston County 1989)

Land use	Acreage
Undeveloped	9,327
Forestry	7,587
Single-family Residential	5,170
Agriculture	4,256
Public Use	969
Multi-family Residential	743
Commercial	736
Mineral Extraction	298
Industrial	189

Budd Inlet/Deschutes Watershed

Budd Inlet is located between Henderson Inlet to the east and Eld Inlet to the west. The inlet is about 7 miles long and has an average width of 1.15 miles. The average depth is 27 feet with a maximum depth of 110 feet occurring near the mouth of the inlet. The inlet is classified as a shallow, poorly mixing estuary. The circulation and mixing pattern in the inlet are primarily driven by a two-layer system; the lower water column flows south toward the head of the inlet, and the upper water column flows north toward the mouth. A variety of land uses occur along the shoreline at the lower portion (southern end) of the inlet; these include undeveloped park shoreline, marinas, residences, and industrial facilities. This urbanized portion of the shoreline accounts for about one-third of the total shoreline. The upper portion (northern end) of the inlet is largely suburban in nature (Thurston County Advance Planning and Historic Preservation [TCAPHP] 1995).

The Budd Inlet/Deschutes Watershed is comprised of 143 identified streams that provide over 256 linear miles of drainage. Total area of the watershed is 118,773 acres. The Deschutes River with its associated tributaries is the largest drainage system within the watershed. The 52 mile-long river drains approximately 166 square miles or about 84% of the total watershed. Other notable streams within the Budd Inlet drainage are Percival/Black Lake Ditch, Ellis, Moxlie/Indian , Adams, Mission and Schneider creeks.

The drainage basin of the Deschutes River drops from the highest point within the watershed, at an elevation of 3,870 feet near Cougar Mountain, to the lowest point near sea level at the river's mouth at Capitol Lake. The upper extent of the river (RM 41 to 52) has a moderately steep gradient. The river drops rapidly over Deschutes Falls at river mile 41, forming a total barrier to fish passage (Williams et al. 1975). Much of the upper watershed lies in the transient snow zone of 1,100 to 3,600 feet elevation. Transient snow zones are areas where rain-on-snow precipitation events are relatively common, making it difficult for hydrologists to estimate runoff and infiltration. The lower 41 miles of drainage consists of a broad prairie-type valley floor that flows mostly through open farmland interspersed with dense stands of mixed deciduous and coniferous growth.

The Percival Creek drainage basin is second in total area within the watershed. It encompasses approximately 9.80 square miles and flows into Budd Inlet via Capitol Lake. The creek has a moderate gradient over most of its length and ranges in width from 9 to 21 feet. It flows approximately 3.3 miles from its headwaters at Trosper Lake through pasture, residential, and forest land to its confluence with Capitol Lake. Much of the drainage is rural with increased development in recent years.

In 1990, about 68,386 people (42.4 %) of the entire population of Thurston County resided within the boundaries of the Budd Inlet/Deschutes Watershed. There were also approximately 19,500 dwelling units. The population within the watershed is expected to increase by 50,000 persons by the year 2015 (TCAPHP 1995). Land use within the watershed (Table 3) is fairly diverse when compared to other watersheds in the South Puget Sound. In the upper third of the watershed, commercial timber production is the primary focus, with some commercial and

Table 3: Land use in the Budd Inlet/Deschutes River watershed (Source - Thurston County 1989)

Land Use	Acreage
Forest cover	74,654
Urban Growth Management Area	13,862
Residential	11,938
Agriculture	10,348
Military	5,986
Industrial	1,280
Utilities	399
Mineral extraction	132
Recreational	128
Commercial	46

non-commercial agricultural ventures overlapping in the lower extent. The middle third of the watershed is comprised of commercial and non-commercial agriculture production with rural residences found throughout the mid-watershed and the outer peninsulas. Land use in the lower watershed, near the mouth of the Deschutes River and inner Budd Inlet, is mostly urban in character (Turner 1993).

Eld Inlet Watershed

The western boundary of WRIA 13 incorporates only the eastern shore of Eld Inlet and its drainages. The western shore of Eld Inlet is part of WRIA 14. The inlet itself has about 30 miles of total shoreline with its widest section stretching 7,000 feet between Frye Cove on the west and Countryside Beach on the east. Cooper Point peninsula is the eastern boundary of the watershed; it extends 7.5 miles into the southernmost reaches of Puget Sound. The highest point on the peninsula is 243 feet just west of The Evergreen State College. The northern end of the peninsula is generally less than a mile across, while its southern end widens to over four miles. The land rises steeply from Puget Sound, with banks often reaching a height of 100 feet within 500 feet of the beach. The steep slopes are indented in many places by draws, ravines and gullies holding small seasonal stream courses. The one exception to this topography is the estuarine area at the southwest corner of the peninsula where the land adjacent to Mud Bay is very low and flat, rising only a few feet above high tide level.

The entire Eld Inlet watershed encompasses approximately 23,220 acres. The primary streams in the watershed are McLane Creek, it's tributaries, and Green Cove Creek. The McLane Creek drainage system incorporates a total of 7,360 acres. It begins in the Black Hills and flows northward, forming Delphi Valley and terminating at the estuary of Mud Bay. The Delphi Valley and surrounding Black Hills exhibit a wide variety of topographies. The highest point is 807 feet in the Black Hills north of Black Lake, while the lowest is Mud Bay at sea level. Cedar Flats and Swift Creeks are the major tributaries of McLane Creek that originate in the Black Hills, while Perkins Creek enters McLane from the Cooper Point peninsula side. Green Cove Creek originates at Grass Lake on the Cooper Point peninsula and runs 3.6 miles north along the eastern boundary of the watershed emptying into Green Cove midway up the peninsula.

As of 1988, the population within the watershed was 6,728 with 2,629 dwelling units. By the year 2010 the population and dwelling units are expected to increase to 12,073 and 4,932 respectively. While houses are generally spread out over the 23,220 acres of the watershed, housing at a density of 1 unit/acre or more can be found all along the saltwater shoreline of Eld Inlet (Eld Inlet Watershed Management Committee 1989). Estimates of acreage currently in various land uses in the Eld Inlet watershed are identified in Table 4.

Table 4: Land use within Eld Inlet watershed (Source – Thurston County 1989)

Land Use	Acreage
Forestry	14,726
Undeveloped	4,602
Suburban residential	1,452
Agriculture	1,188
Public	1,175
Commercial	55
Mineral extraction	9
Industrial	0

DISTRIBUTION AND CONDITION OF NATURAL SPAWNING POPULATIONS

The salmonid species that are being considered in the ESHB 2496 assessment of limiting habitat factors are chinook (Oncorhynchus tshawytscha), chum (O. keta), pink (O. gorbuscha), coho (O. kisutch), sockeye (O. nerka), steelhead (O. mykiss), and bull trout/dolly varden (S. confluentus/S. malma). Of these, only chinook, chum, coho, and steelhead are known to occur persistently in WRIA 13. Pink and sockeye have been observed infrequently in low numbers in certain streams, and are believed to be strays from other streams of origin.

The known distributions of chinook, chum, coho, and steelhead are represented in Figure 3 to Figure 6; composite distribution for all four species is represented in Figure 7. Salmonid distribution was identified using Streamnet (stream database managed by WDFW), the Spawner Survey Database (records of spawner counts in streams, managed by WDFW), and the collective experience of TAG participants and key WDFW and tribal staff. Source documentation for the designated species distribution is shown in Table 7 (river mile references are from Williams et al. 1975). Spawning and rearing distributions are assumed to extend from the mouth of each stream to the designated uppermost extent of distribution, except for the Deschutes River where there is no known spawning from the tide gate on Capitol Lake upstream to just above Tumwater Falls. Uppermost distribution of a species on any stream is limited by natural characteristics of the stream (size, gradient, lack of flow, etc.), by natural barriers to migration (Deschutes Falls), or by artificial, human-constructed obstacles (culverts, weirs, dams, etc.). Evaluations to determine uppermost extent of juvenile salmon rearing has not been done for most streams in WRIA 13. Artificial barriers are identified in the section of this document on fish passage barriers.

Chinook

Known distribution of chinook salmon in WRIA 13 is represented in Figure 3 and Table 7. The Salmon and Steelhead Stock Inventory (SASSI) [Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes (WDFW and WWTIT) 1994] identifies South Sound Tributaries Summer/Fall Chinook as a stock tentatively classified as distinct based upon geographical distribution, but reflects populations of chinook in several rivers in WRIAs 12-15. There are no genetic stock identification data for naturally spawning South Sound chinook. An examination of the genetic composition of Deschutes Hatchery chinook in 1981 and 1987 is included in SASSI, which concluded that the baseline was not significantly different from the Skagit Hatchery fall chinook baseline. This grouping of seemingly widely distributed chinook was likely the result of extensive stock transfers from basin to basin and considerable hatchery outplantings and straying in south Puget Sound. The stock was designated as mixed origin and of healthy status (WDFW and WWTIT 1994).

WRIA 13 chinook are hatchery origin chinook returning to the Deschutes River. Chinook, as well as other anadromous salmon and steelhead, were introduced into the Deschutes River in the late 1950s. Historically, anadromy in the Deschutes River extended only to the base of Tumwater Falls. Spawning time peaks in October. Most chinook are taken at the Deschutes Hatchery with limited release upstream. Table 5 identifies the numbers of chinook released upstream of the hatchery rack in recent years. Chinook passage upstream of the hatchery rack was not necessarily for the purpose of developing or encouraging natural production; rather, it was generally a result of passing chinook surplus to hatchery needs that would otherwise have been sold as surplus carcasses. Dave Seiler (WDFW , personal communication) indicates there is evidence of a significant decline in the Deschutes chinook run in the last couple years, reflecting similar trends observed for coho.

Additional chinook spawners have been documented in other WRIA 13 streams. Within the Deschutes River watershed, chinook have been documented in Spurgeon, Mitchell, Huckleberry, Thurston, and Unnamed (13.0102) creeks. Elsewhere in WRIA 13, chinook spawners have been observed annually in Percival Creek/Black Lake Ditch (13.0030), Woodland Creek, and McLane/Swift creeks. All of these creeks are smaller and have less flow than typical chinook streams, but may have limited habitat capable of supporting low numbers of chinook. There is also reason to believe that the chinook spawners are strays from fish enhancement operations in close proximity to these streams. To what extent these chinook are hatchery strays vs. natural self-sustaining is unknown, though it is unlikely that natural chinook populations existed in these streams prior to regional enhancement efforts. Chinook presence has also been documented in Indian, Moxlie, and Ayer (Elwanger, 13.0036) creeks, all of which are considered by state and tribal biologists as being too small to support any chinook production. Chinook presence in these streams is considered to be strictly the result of straying of hatchery origin chinook.

Table 5: Chinook released upstream of Deschutes Hatchery (Source – WDFW, Pete Topping)

Return Year	Males	Females	Jacks	Total
1985	241	159	305	705
1986	42	43	57	142
1987	182	58	417	657
1988	28	67	6028	6123
1989	574	385	587	1546
1990	2195	2898	894	5987
1991	118	5	72	195
1992	220	11	633	864
1993	76	17	0	93
1994	410	521	560	1491
1995	2564	2305	103	4972
1996	3970	4262	308	8540
1997	327	6	30	363
1998	901	553	292	1746

[Note: Jacks are precocious males that return to spawn prior to the normal maturation age.]

Chum

Known distribution of chum salmon in WRIA 13 is represented in Figure 4 and Table 7. SASSI identifies two distinct stocks of fall chum in WRIA 13, Henderson Inlet fall chum and Eld Inlet fall chum (WDFW and WWTIT 1994). South Sound fall chum enter the terminal area between the first week in October and the first week in January. Spawning begins about the third week in October and may continue through January. Henderson Inlet fall chum were identified as a stock because they are isolated from other Puget Sound stocks by geographic separation (the result of subjective judgements regarding the probability of significant spawner interchange between those drainages). The primary spawning tributaries in Henderson Inlet are Woodland and Woodard creeks (WDFW and WWTIT 1994), with additional spawning identified in Mill (13.0001), Dobbs, and Fox creeks. Hatchery chum stocks from Elson and Minter creeks have been planted in both Woodard and Woodland creeks, so they could be described as mixed stock from composite production. However, Woodard Creek may still have a remnant native run (WDFW and WWTIT 1994). SASSI identified this stock's status as unknown, but noted that severe habitat degradation due to development and alteration of flow regimes has impacted the productivity of salmonid species in this basin.

Eld Inlet fall chum were identified in SASSI as a stock isolated from other Puget Sound stocks by geographic separation and as being genetically distinct from other Puget Sound fall chum stocks. Eld Inlet is included in both WRIAs 13 and 14, with the major spawning tributaries in WRIA 13 being McLane and Swift creeks. Additional chum spawning has been identified in Green Cove, Sunset (13.0135), Houston, Perkins, and Cedar Flats creeks. Hatchery plants in McLane Creek using Hood Canal chum were made, but whether these plants were successful is unknown. There are no records of chum plants in Swift Creek, so the stock should be considered as native; the status of the stock is designated as healthy (WDFW and WWTIT 1994).

Additional limited fall chum spawning has been documented in tributaries to Budd Inlet, including Adams/Unnamed tributary, Ellis, Mission, Indian, Moxlie, Percival, and Black Lake Ditch (13.0030) creeks. Chum returning to these streams are not specifically designated as a separate stock in SASSI and there is no designation of stock status.

Coho

Known distribution of coho salmon in WRIA 13 is represented in Figure 5 and Table 7. Two separate stocks of coho are identified in SASSI within WRIA 13, South Sound/Deschutes and South Sound/Deep South Sound coho stocks. There is a history of substantial outplanting of hatchery origin coho in these drainages dating back to the 1940-1950s, as well as straying from net pen facilities that could represent a significant portion (10-20%) of the average total spawning escapement to these systems (WDFW and WWTIT, 1994). However, Deschutes River adult return data (
Table 6) indicates that hatchery origin coho comprise <3% of the total escapement in most recent years, and the actual number of hatchery origin coho in the escapement is very low in all years. The distinction of the South Sound/Deschutes stock from those in surrounding drainages is dependent upon a determination of geographic spawning separation and the dissimilarity in planting histories between this and surrounding stocks (which would suggest different impacts, further supporting separation). Until a genetic determinant is available and used to evaluate these stocks, the distinction is tentative (WDFW and WWTIT, 1994). In addition to the Deschutes River and its tributaries, coho spawning is identified in Dobbs, Woodland, Fox, Jorgensen, Woodard, Adams/Unnamed tributary (13.0018 and .0021), Ellis, Mission, Indian, Moxlie, Percival, Black Lake Ditch (13.0030), Schneider, Green Cove, Sunset (13.0135), Houston, McLane, Swift, Perkins, Cedar Flats, and Unnamed (13.0142) creeks.

The Deschutes stock origin is identified in SASSI as non-native, whereas the stock origin for Deep South Sound Tributaries is identified as mixed. The Deschutes stock production type is identified as wild, whereas the production type for Deep South Sound Tribs. is identified as composite. The stock status for both stocks was identified in SASSI as healthy. However, the co-managers (WDFW and Squaxin Island tribe) agree that the stock status for Deschutes should be reconsidered as depressed or critical given continuation of the low spawning escapements observed since 1989 (Table 6). This reconsideration of status may also be warranted for the Deep South Sound Tribs. coho stock.

Extremely low returns are predicted by WDFW (Dave Seiler, personal communication) to continue, with the 1998 smolt outmigration estimated at only 6,000 coho. Marine survival for Deschutes coho has been very low in recent years, with estimated survival being below 10% for

Figure 2: Marine survival of four Puget Sound coho stocks (Source - 1/22/99 memo from Seiler, WDFW)

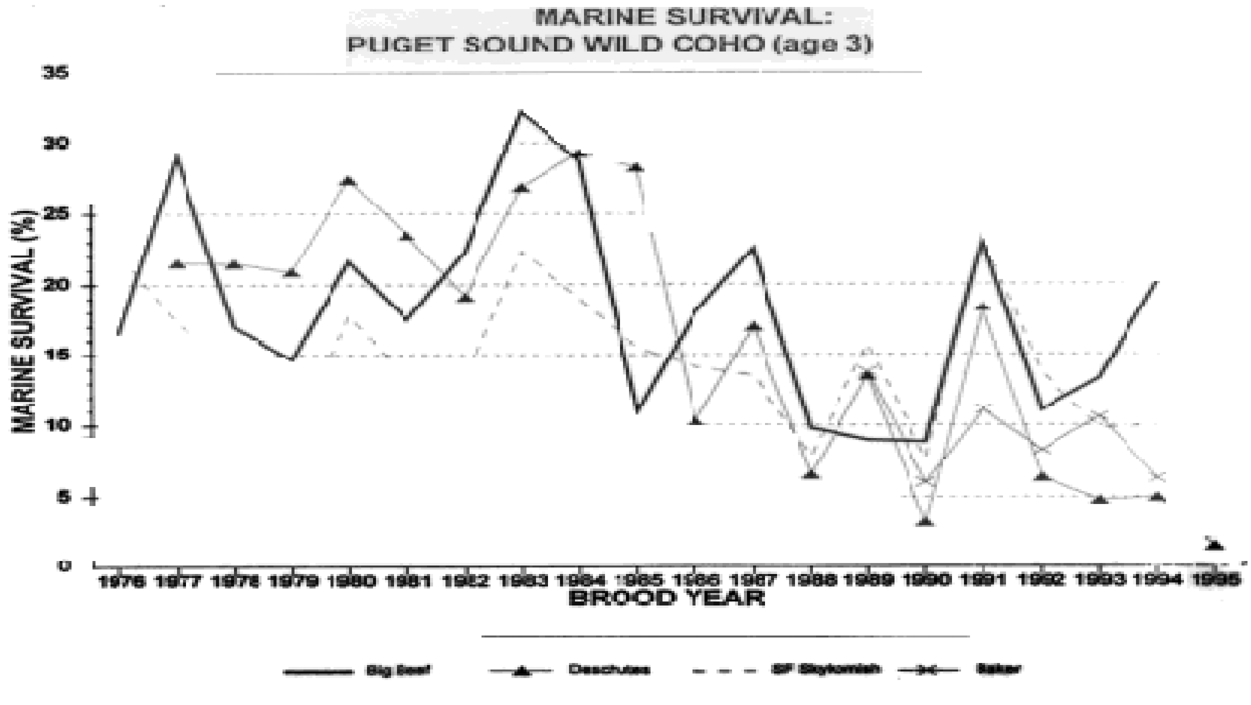

Table 6: Estimated total and wild adult coho returning to the Deschutes River fishway (Source – Pete Topping, personal communication)

Return Year	Total Coho Return	Est. Percent Wild
1980	3010	95.75
1981	4508	85.25
1982	8959	96.04
1983	4840	95.87
1984	4630	99.24
1985	6011	98.72
1986	4652	96.84
1987	10,397	99.98
1988	7592	99.95
1989	974	100.00
1990	3033	98.91
1991	1984	99.85
1992	530	79.62
1993	660	96.82
1994	2757	98.30
1995	596	97.65
1996	511	97.46
1997	1092	98.08
1998	85	62.35

six of the last eight years, and below 5% for four of the last six years (Figure 2, Source 1/22/99 memo from Seiler, WDFW).

Winter Steelhead

Known distribution of winter steelheadn in WRIA 13 is represented in Figure 6 and Table 7. Two distinct stocks of winter steelhead have been identified in WRIA 13; Deschutes winter steelhead and Eld Inlet winter steelhead. Wild winter steelhead in the Deschutes River and tributaries are a distinct non-native stock based on the geographical isolation of the spawning population. Run timing is generally from November to mid-March and spawn timing is generally from early January to early April (WDFW and WWTIT, 1994). For this winter steelhead stock, spawning has been identified in the mainstem Deschutes River and in Offut Lake Outlet (13.0040), Silver springs, Unnamed (13.0042), Reichel, Fall, Mitchell, and Johnson creeks. The stock origin is identified as non-native, but continuing production is wild. The stock status is identified as healthy, although it has experienced a decline in recent years similar to that observed for coho (Dave Seiler, personal communication). The status of this stock warrants further evaluation.

Eld Inlet wild winter steelhead are native to the drainages and a distinct stock based on the geographical distribution of the spawning populations. Eld Inlet is split between WRIAs 13 and 14. The primary spawning tributary in WRIA 13 is McLane Creek. Run timing is generally from December through mid-March, with spawning generally from early February to early April. The status of the stock is unknown. The stock is comprised of a historically small number of steelhead, but there is insufficient information to classify its status as healthy, depressed, or critical (WDFW and WWTIT 1994). For this winter steelhead stock, spawning has been identified in Green Cove and Perkins creeks. Winter steelhead presence is also likely in McLane Creek, although no survey indications of presence were located.

Other streams in WRIA 13 that have identified winter steelhead escapement not specifically associated with either of the designated SASSI stocks include Woodland and Woodard creeks.

Pink

There have been isolated observations of pink salmon spawning presence in Mill (13.0001) and Swift creeks (WDFW Spawner Survey Database) and the Deschutes River (personal communication, Pete Topping) in WRIA 13. There is insufficient information to identify pink as a persistent stock in any of the WRIA 13 streams.

Sockeye

There are isolated observations of riverine sockeye salmon spawning presence in Woodland, Percival, Black Lake Ditch, and Perkins creeks in WRIA 13. There are annual observations of very low (<10 fish) returns of adult sockeye to the Deschutes River (Topping, personal communication). There is insufficient information to identify sockeye as a persistent stock in any of the WRIA 13 streams.

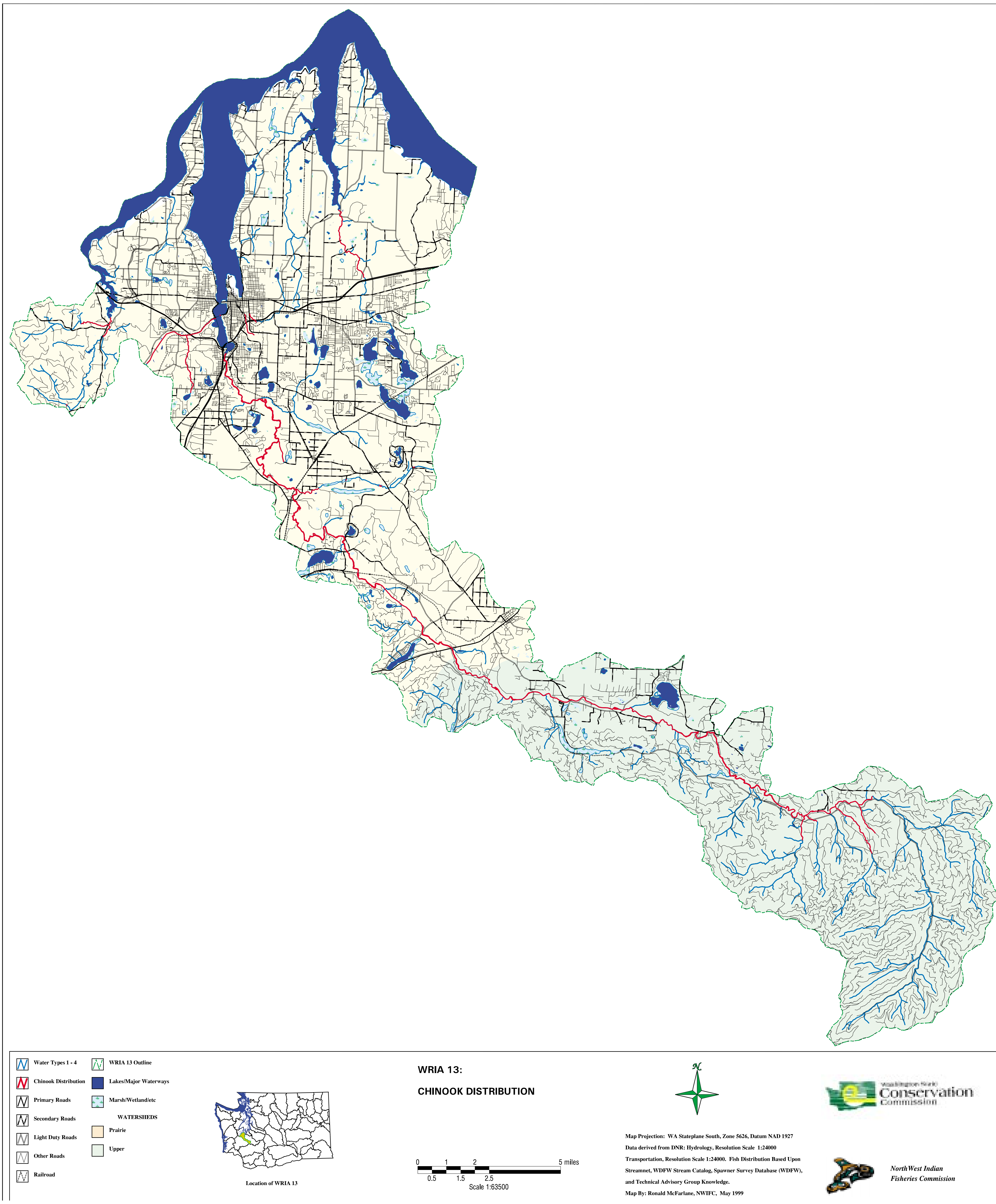

Figure 3: Known distribution of chinook salmon in WRIA 13

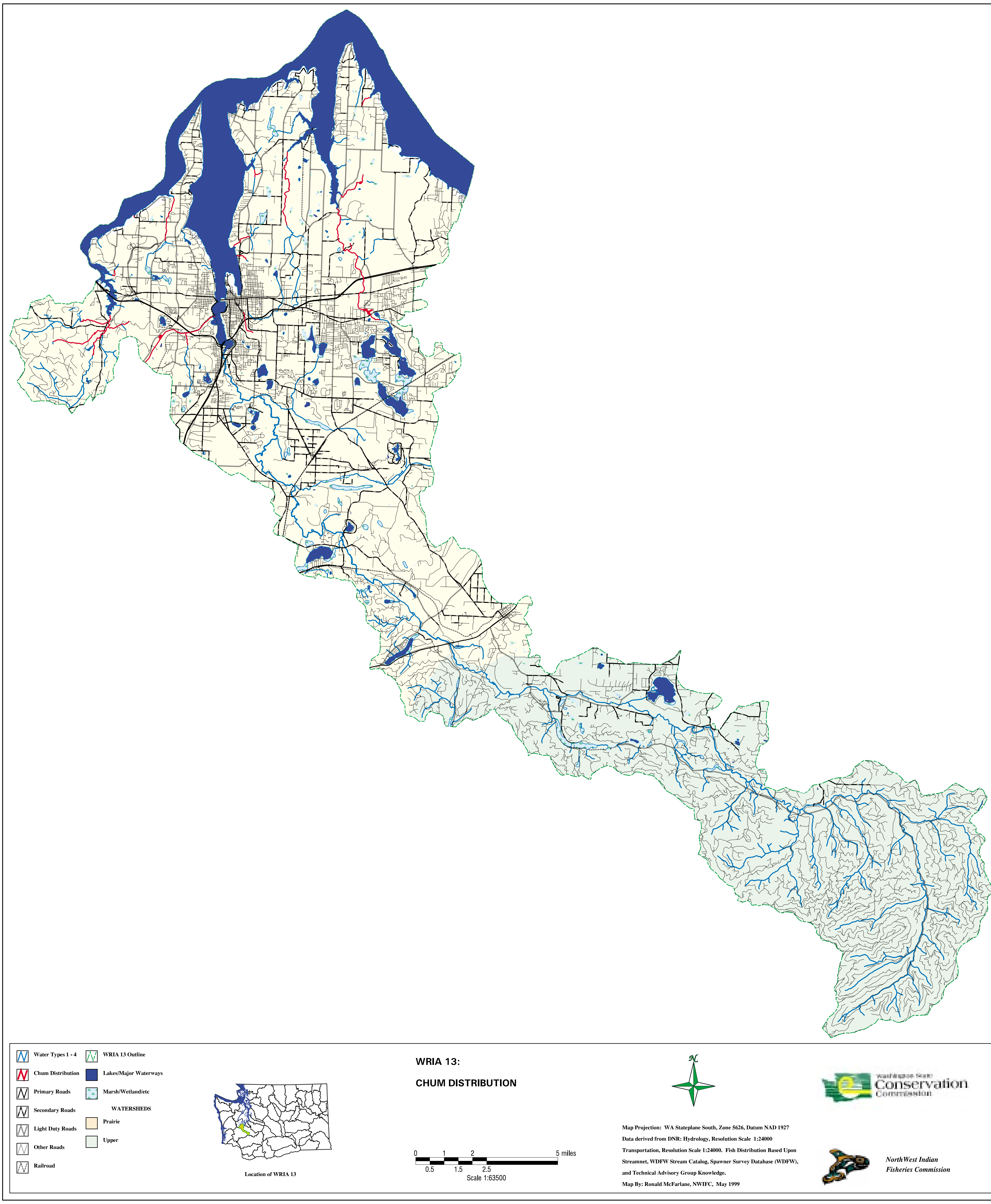

Figure 4: Known distribution of chum salmon in WRIA 13

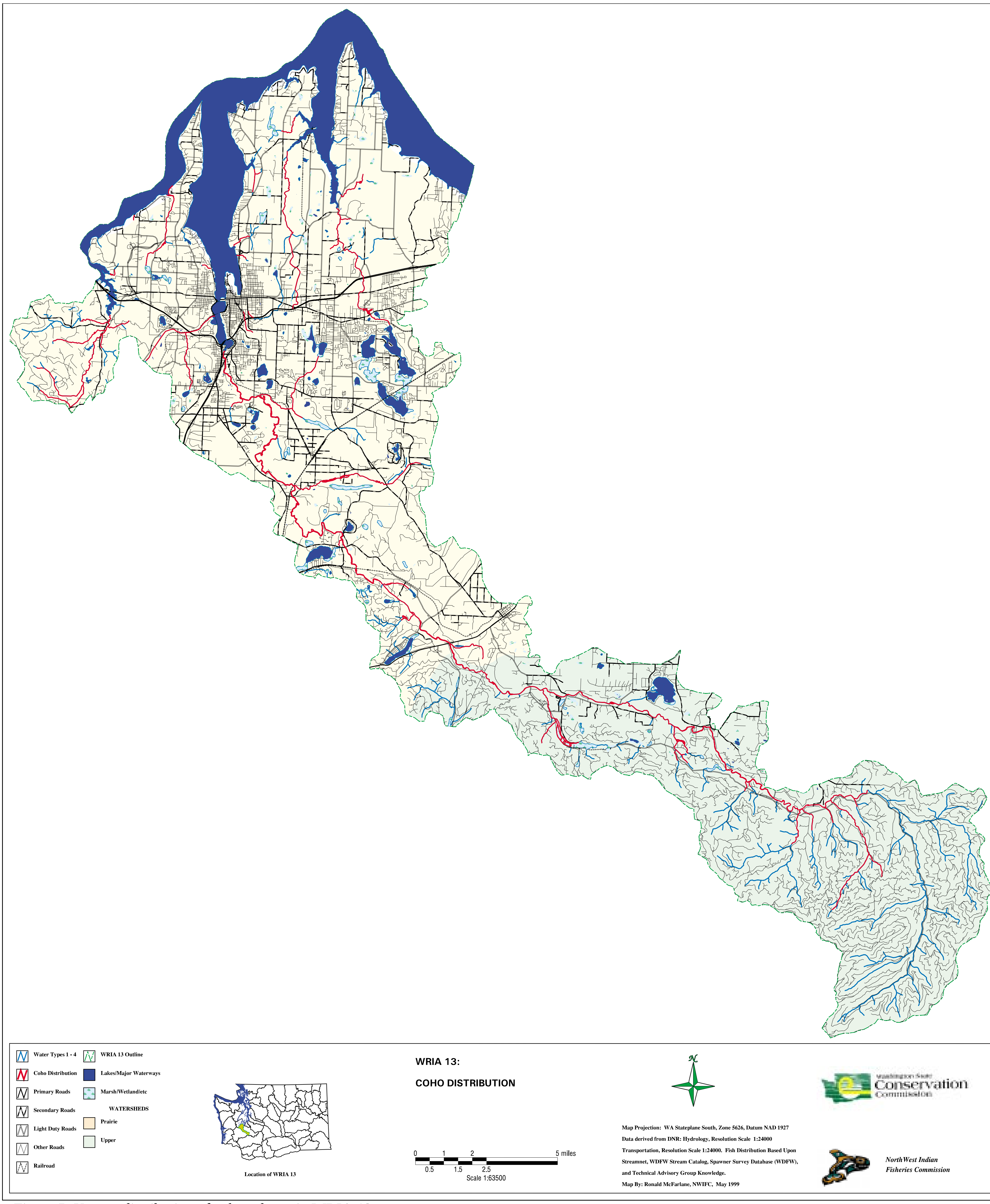

Figure 5: Known distribution of coho salmon in WRIA 13

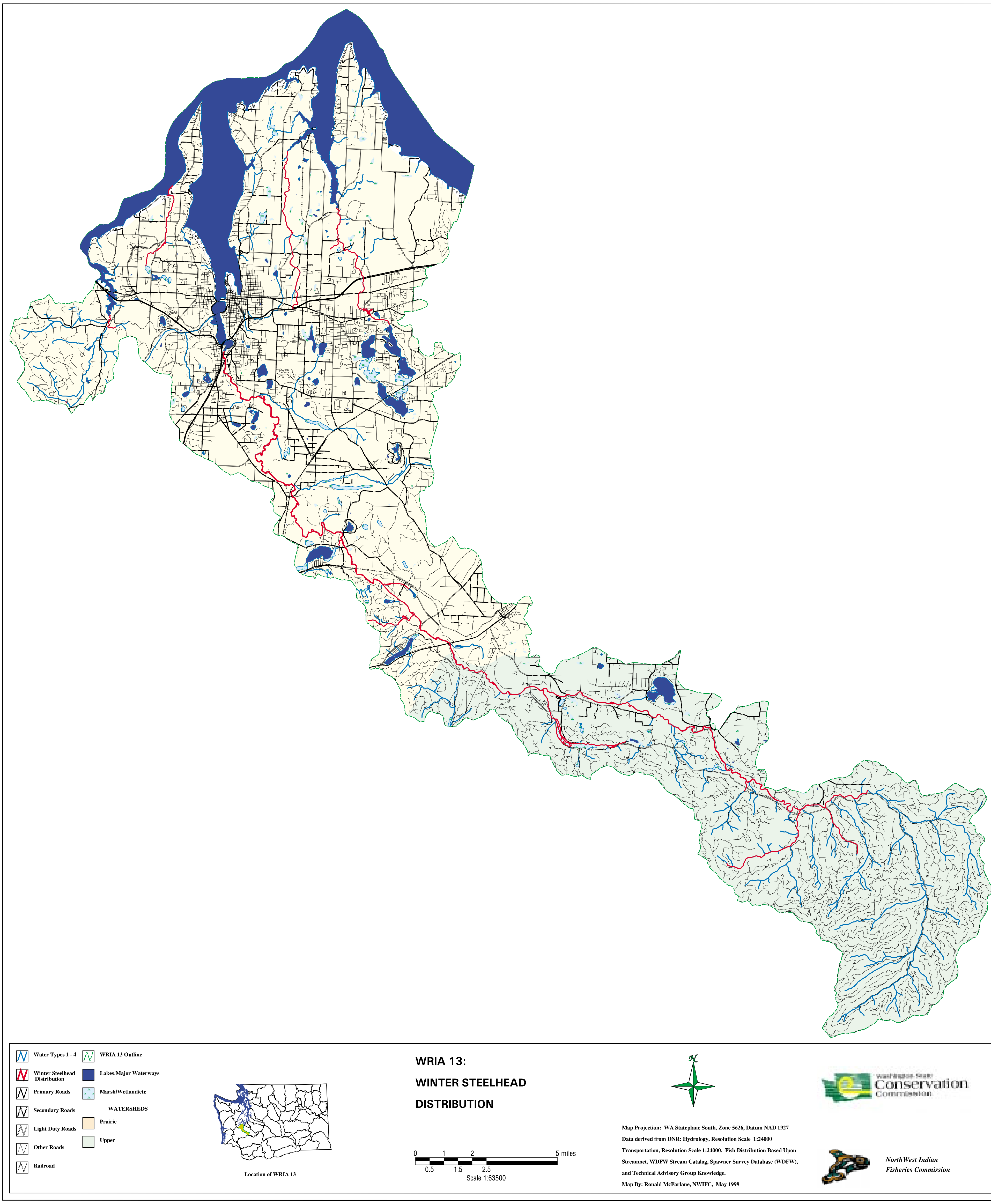

Figure 6: Known distribution of winter steelhead in WRIA 13

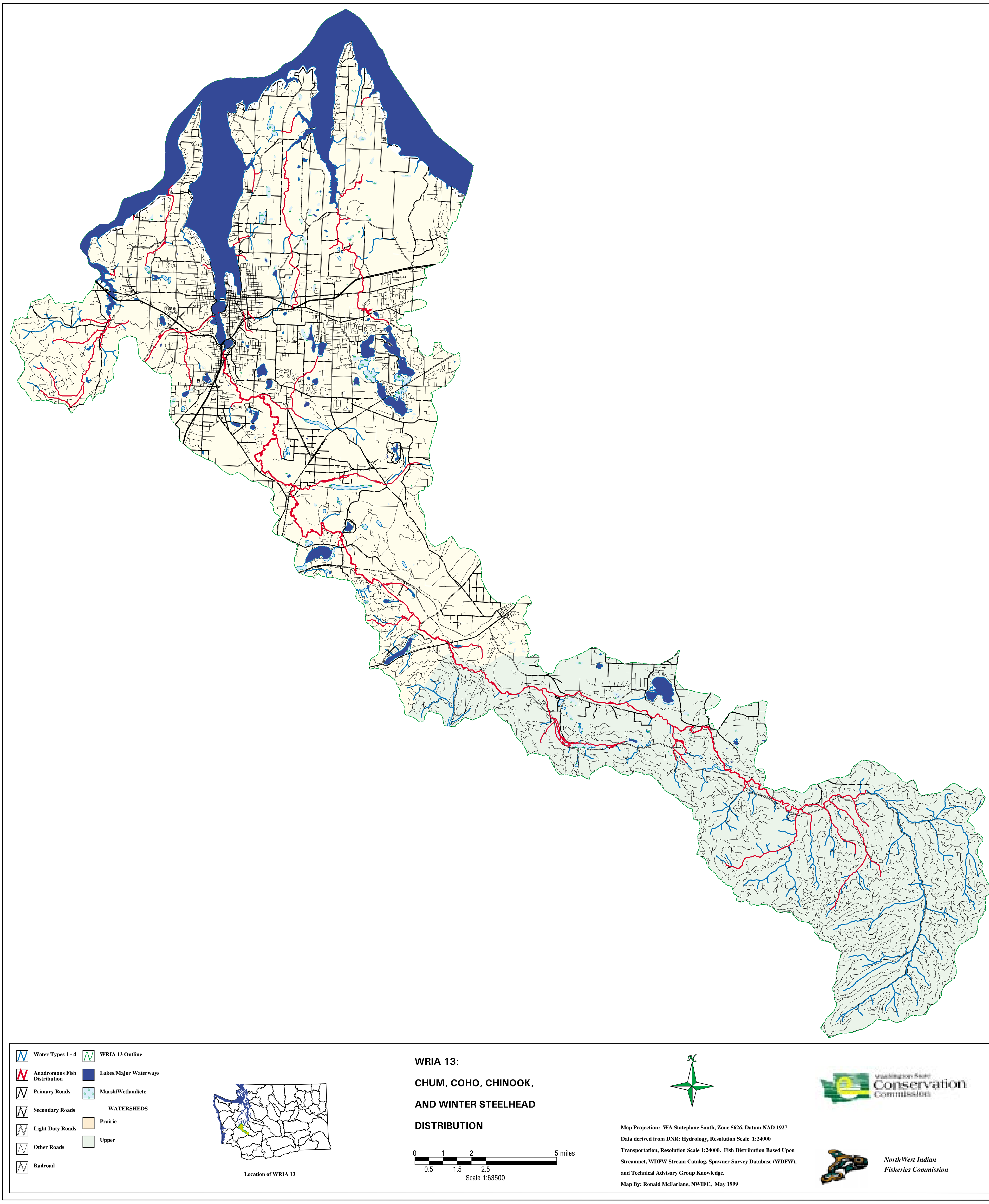

Figure 7: Known composite distribution of chinook, chum and salmon and winter steelhead in WRIA 13

Table 7: WRIA 13 salmon and winter steelhead distribution source information

STREAM NAME	WRIA INDEX	SPECIES	UPPERMOST DIST. (RM)	COMMENT
Unnamed	13.0001	Chum	1.00	
		Pink	1.00	
Dobbs Creek	13.0005	Coho	1.50	
		Chum	1.50	
Woodland Creek	13.0006	Chinook	3.10	SN reports presence to RM 2.9
		Coho	5.10	SSD reflects survey presence to RM 4.4
		Chum	5.00	SSD reflects survey presence to RM 4.4, chum presence limited upstream of Martin Way and particularly upstream of the lower end of Lake Lois (Baranski, Haymes)
		W. Steelhead	5.10	SN indicates presence to RM 4.9, no reason that Steelhead would not go at least as far upstream as coho (Baranski) so moved to RM 5.1, SSD reflects survey presence to RM 4.4
		Sockeye	4.40	
"Fox Hollow Cr."	13.0007	Coho	0.40	
Jorgenson Cr.	13.0008	Coho	0.40	
Fox Cr.	13.0009	Chum	0.30	
Eagle Creek	13.0010	Coho	1.10	
Woodard Creek	13.0012	Coho	7.00	SSD reflects survey presence to RM 6.8
		Chum	3.60	
		W. Steelhead	7.00	
Sleepy Creek	13.0015	Coho	1.00	
Adams Creek	13.0018	Coho	1.40	
		Chum	0.30	
		Cutthroat	1.50	
Unnamed	13.0021	Coho	0.30	
		Chum	0.30	
		Cutthroat	0.30	
Ellis Creek	13.0022	Coho	0.40	

		Chum	0.40	
Mission Creek	13.0025	Coho	0.40	
		Chum	0.40	
Indian Creek	13.0026	Chinook	1.10	
		Coho	1.20	Personal observations of Jim Lenzi
		Chum	Unknown	
Moxlie Cr.	13.0027	Chinook	1.10	
		Coho	1.10	
		Chum	1.10	
Percival Creek	13.0029	Chinook	3.30	
		Coho	3.30	
		Chum	1.50	
		Cutthroat	3.30	
Black Lake Ditch	13.0030	Chinook	2.20	SSD reflects survey presence to RM 3.3
		Coho	2.20	
		Chum	2.20	
		Sockeye	0.50	
Deschutes River	13.0028	Chinook	41.00	SSD reflects survey presence to Rm 39.3
		Coho	41.00	SSD reflects survey presence to RM 40.8
		W. Steelhead	41.00	
		Cutthroat	41.00	
Unnamed	13.0032	Coho	0.50	
Chambers Cr.	13.0033	Coho	3.75	SSD reflects survey presence to RM 0.6
		Cutthroat	3.75	
Unnamed	13.0034	Coho	0.50	
		Cutthroat	0.50	
Unnamed	13.0036	Chinook	1.00	
Spurgeon Cr.	13.0037	Chinook	1.00	
		Coho	5.20	SN reflects survey presence to RM 5.0
Offut Lake Outlet	13.0040	Coho	0.25	
		W. Steelhead	0.25	
Silver Springs	13.0041	Coho	1.00	

		W. Steelhead	1.00	
Unnamed	13.0042	Coho	0.60	SN reflects survey presence to RM 0.1
		W. Steelhead	2.00	
Unnamed	13.0045	Coho	1.60	
Reichel Cr.	13.0046	Coho	2.80	
		W. Steelhead	4.50	
Unnamed	13.0047	Coho	1.10	
Pipeline Cr.	13.0051	Coho	1.50	
Unnamed	13.0052	Coho	1.00	
Hull Cr.	13.0053	Coho	1.80	
Fall Cr.	13.0057	Coho	0.25	SSD reflects survey presence to 0.3, but probably same point
		W. Steelhead	0.25	
		Cutthroat	0.25	
Unnamed	13.0066	Coho	0.25	
Mitchell Cr.	13.0069	Chinook	0.90	
		Coho	1.30	SSD reflects survey presence to 0.9
		W. Steelhead	4.00	
		Cutthroat	4.00	
Huckleberry Cr.	13.0086	Chinook	0.40	Flow limits chinook access and spawning most years (CB)
		Coho	1.20	SN reflects presence to RM 1.1
		Cutthroat	1.10	
Johnson Cr.	13.0089	Coho	0.70	SN reflects presence to RM 0.5
		W. Steelhead	2.60	
Thurston Cr.	13.0095	Chinook	2.30	SSD reflects survey presence to RM 1.7
		Coho	5.00	SSD reflects survey presence to RM 1.7
		W. Steelhead	Unknown	
Unnamed	13.0097	Coho	1.00	
Unnamed	13.0102	Chinook	2.00	
		Coho	0.40	SSD reflects survey presence to RM 0.2
Schneider Cr.	13.0131	Coho	0.25	
		Cutthroat	0.25	
Green Cove Creek	13.0133	Coho	3.40	SSD reflects survey presence to RM 1.7
		Chum	1.80	

		W. Steelhead	3.40	
Unnamed	13.0135	Coho	0.70	
		Chum	0.10	
Houston Creek	13.0137	Coho	0.20	Jim Fraser reports likely coho presence to above County Rd. due to culvert corrections in 1999
		Chum	0.00	
McLane Creek	13.0138	Chinook	0.90	SN reflects presence to RM 0.4
		Coho	1.00	
		Chum	2.00	CAT reflects presence to RM 3.5
		Cutthroat	3.50	
Swift Cr.	13.0139	Chinook	1.00	
		Coho	1.00	
		Chum	1.00	SN reflects presence to RM 1.0
		Pink	1.00	
		Cutthroat	1.00	
Perkins Creek	13.0140	Coho	1.10	SN reflects presence to RM 1.0
		Chum	1.10	SSD reflects survey presence to RM 0.7
		W. Steelhead	0.50	
		Sockeye	0.50	
		Cutthroat	1.10	
Cedar Flats Cr.	13.0141	Coho	2.00	
		Chum	2.00	
		Cutthroat	2.00	
Unnamed	13.0142	Coho	0.75	
		Cutthroat	0.75	
Beatty Cr.	13.0143	Coho	1.00	SSD reflects survey presence to RM 5.3, likely in error
		Cutthroat	1.00	

NOTE: Source acronyms are:
SSD=Spawner Survey Database (maintained by WDFW),
SN=Streamnet (maintained by WDFW),
TAG=Technical Advisory Group,
SASSI=Salmon ad Steelhead Stock Inventory (WDFW & WWTIT, 1992)
CAT=WDFW Stream Catalog (1971)
JL=Jim Lenzi, WDFW

WRIA 13 HABITAT LIMITING FACTORS CONCLUSIONS BY FACTOR TYPE

This chapter presents habitat limiting factor conclusions by factor type. This provides an opportunity to look at each of the key habitat elements and identify common themes across drainages in WRIA 13. Most restoration projects will likely be targeted at specific streams, but it is important to understand each stream in the broader context of the WRIA. The major habitat factors that are presented in this chapter include:

- access to spawning and rearing habitats,
- substrate,
- floodplains,
- riparian buffer width,
- water quality,
- water quantity,
- biological processes.
- lakes, and
- estuarine.

Data presented in this chapter is limited to those streams on which studies or observations have been made. The lack of mention of any particular stream in discussion of a habitat element likely reflects that no data or studies are available. However, the habitat element may be of concern if observations or investigations were to be made.

Access to Spawning and Rearing Habitats

Natural features of the landscape limit salmon spawning and rearing. They include channel gradient (cascades, falls) and other characteristics of the landscape (channel constrictions, beaver dams, log jams, etc.). Flow can affect whether certain physical features are barriers. For example, some falls or cascades may be impassable at low flows, but become passable at higher flows. Low flows can present a barrier to upstream and downstream salmon; at higher flows fish are not blocked. Conversely, areas where channels are naturally constricted may be passable at lower flows, but increased water velocity at higher flows may prevent fish passage. Different salmonid species and life stages (adult and juvenile) are affected differentially by passage conditions, so each site must be reviewed in terms of species and life stage(s) affected. The modification of natural barriers is not considered in this report on habitat limiting factors, rather, the report focuses on human-caused factors that are limiting salmonid productivity.

In addition to natural barriers, construction of road crossings, dams, and fish screens have created fish passage barriers that restrict or prevent juvenile and adult salmon from gaining access to formerly accessible habitat. The most obvious of these barriers are dams and water diversions that prevent fish passage. However, in recent years it has become increasingly clear that we have also constructed barriers that prevent juveniles from accessing rearing habitat. For example, poorly designed culverts in streams have impacted the ability of salmon adults and juveniles to access large reaches of streams. In estuaries, dikes and levees have blocked access to sloughs and tidal marshes previously used by salmon for rearing, and transition from fresh to salt water. Other barriers include bridges that constrict the channel, tide gates, private ponds, etc.

Dams and Diversions

The waters of the Deschutes River and Percival Creek flow into Capitol Lake, which is a human-made lake backed up behind a tide gate under 5th Avenue in downtown Olympia. Salmon can pass this tide gate, either through the constructed fishway or directly through the tide gate when open. Large numbers of chinook salmon are observed downstream of the tide gate in August and early September. Although the tide gate and fishway may be a barrier at certain tidal elevations, chinook pass effectively upstream into the lake. During their milling below the tide gate, however, they are exposed to increased predation from seals and sea lions known to frequent the area. The tide gate and fishway are a known barrier for winter steelhead, requiring repair or replacement to ensure free and unobstructed passage. [Note: Washington Department of General Administration indicates repair will occur next biennium.]

Adult salmonids are impacted at the Capitol Lake tide gate by impaired function of the fish ladder. Tidal water is not allowed to flow freely into the lake, and the lake level is maintained within a narrow range. A fish ladder was installed to provide passage for salmonids at varying tidal stages. Chinook are also known to enter the lake through the tide gate opening under certain conditions. The entrance to the fish ladder at the dam is at elevation 5.0 ft. MSL, but is not operational until the lake is above elevation 5.5 ft. MSL. During winter, the lake level is maintained at an elevation of 5.4 ft. MSL to provide for additional flooding protection to downtown Olympia. However, this elevation does not allow adult salmon to use the ladder (Darin Cramer, personal communication). Adult salmonids are likely delayed in their upstream migration when the tide gate is closed and there is no flow through the ladder. This delay may result in increased predation by marine mammals. The species primarily affected by the tide gate and fish ladder are thought to be chum and steelhead, which return during late-fall/winter when the reduced lake level impairs proper function of the fish ladder.

Periodic installation and operation of a screen at the outlet of Percival Cove adjacent to Deschutes Parkway impair migration of juvenile and adult salmonids from and to Percival Creek and Black Lake Ditch. The duration of time that juvenile and adult screening has been in place has been reduced over the last 20 years, but still occurs in a manner that significantly affects natural salmon production in Percival Creek and Black Lake Ditch (Keith Keown, personal communication). A fine-meshed screen is installed from approximately April 1 through May 15 to retain Age 0 and yearling chinook that are being reared by WDFW in Percival Cove. On May 15 the screens are removed, allowing the reared chinook and other anadromous salmonids to emigrate from Percival Cove. It is likely, however, that much of the natural juvenile salmon and steelhead production attempting to migrate from Percival Creek and Black Lake Ditch may be delayed in their migration, which may adversely affects survival. Returning adult salmon (chinook) are also impaired in their ability to migrate freely to Percival Creek and Black Lake Ditch. Pickets (spaced approx. 1.5 inches) are installed approximately August 10 and not removed until the Deschutes hatchery egg take is assured (approximately September 30). The intent is to maximize the return of adult chinook to the hatchery facility at Tumwater Falls. However, this effort prevents the return of chinook to Percival Creek from the early portion of the run, and limits the number of chinook returning to Percival Creek and Black Lake Ditch, two of the four streams in WRIA 13 that have potential to support limited natural chinook production.

Action Recommendation – The following salmonid habitat restoration actions are recommended:

- fix the Capitol Lake tide gate and fishway to allow adult fish passage at all tidal stages and lake levels,
- conduct further analysis of the impact of delayed migration into Capitol Lake due to the presence of the dam and tide gate, and

- identify and correct adverse impacts from the Percival Cove screen to any naturally-produced adult and juvenile salmonids that may be originating from Percival Creek.

Culverts

Perhaps the most frequently encountered fish passage barriers are culverts that are improperly designed, installed, or maintained, and channel alterations that result in impassable conditions. A statewide inventory of passage conditions associated with culverts owned by Washington State Department of Transportation has been completed. In addition, Thurston County is one of only two counties in the state where a comprehensive inventory of passage conditions for all county-owned culverts has also been completed. A comprehensive assessment of other fish passage barriers (private culverts, private dams, etc.) has not been completed for WRIA 13, although information for some sites is available.

Information for inventoried culverts (passable and impassable) is contained in the Washington Department of Fish and Wildlife: Fish Passage Barrier Database (WDFW Salmon and Steelhead Habitat Evaluation and Rehabilitation [SSHEAR] 1999). These culverts have been assessed for ability of salmonids to freely pass through the culvert. The WRIA 13 Fish Passage Barrier Database (edited to remove duplicate entries for passage barriers in WRIA 13) includes 168 culverts for which geographic coordinates can be identified (four additional records are included in the database, but specific geographic coordinates could not be readily determined). Of the 172 culverts inventoried in WRIA 13, 62 were identified as barriers to fish migration, and 110 were identified as not being barriers at this time (Figure 8, Table 8). Culverts identified as barriers (Figure 8, Table 9) may be total barriers to fish passage, or partial barriers (passage precluded at certain flow conditions, for certain species, or at certain life stages). Where habitat conditions have been assessed upstream of barriers, a Priority Habitat Index value may be assigned, which is a relative indicator of benefit if the barrier were corrected. This index value is a reflection of the quantity and/or quality of habitat upstream of the barrier and can be used in the restoration prioritization process. Additional site specific data can be obtained from SSHEAR. Culverts that were identified as not being barriers at the time of inventory may become barriers as stream beds change at the site, and monitoring of these sites should continue over time to ensure that fish passage conditions are maintained.

In addition to the culvert data included in the WDFW Fish Barrier Database, the WRIA 13 TAG identified a barrier culvert in "Fox Hollow" Creek (13.0007). The culverts on Woodland Creek under Pleasant Glade Road (Thurston culvert inventory numbers 10094 and 10095) are identified in the WDFW Fish Barrier Database (SSHEAR 1999) as not being barriers, but recent observations by Scott Brummer of the Thurston Conservation indicate a significant drop at the outlet of the culvert(s). The culverts are likely a barrier to fish migration at certain (possibly all) flow levels.

Information on the occurrence of culverts in the forest management zone of the upper Deschutes watershed is also limited. Sullivan et al. (1987) identify 1,097 culverts in the upper Deschutes watershed including tributaries (1980 existing road network)(Table 10). Of these, 391 (33%) had direct entry to streams, most of which (88%) drain directly to Type 4 or 5 streams. [NOTE: Stream typing criteria are identified in the Washington Forest Practice Rules and Regulations. Although Type 4 and 5 streams are considered to not be fish bearing, it has been found that a significant percentage of streams designated as Type 4 or 5 actually support salmonids. An emergency rule has been adopted by the Forest Practices Board to protect streams previously designated as Type 4 and 5 that meet certain physical criteria.] The drainage length encased in the 391 culverts draining directly to streams is 82,627 m. (51.6 miles). Many of these culverts may be upstream of the uppermost anadromous extent, and the effects to fish passage are unknown. However, the length of streams encased in culverts represents a significant loss of natural stream function.

Culverts and associated road fills, regardless of their associated land use, also pose a significant erosion and mass wasting hazard with blockage of the culvert and associated overflow during high flow events. Toth (1991) identified that, as the result of a 100+ year storm event in January, 1990, a significant number of slides and mass failures occurred in the upper Deschutes River watershed. Of the hundreds of sites that incurred varying degrees of damage, a subsample of 76 sites (chosen by the Vail Tree Farm road engineer) were evaluated. Seventy percent of the sites had problems because of road construction-related causes, while 17% were associated with road maintenance-related causes. A combination of construction and maintenance-related causes was found at 13% of the sites. Twenty nine percent (21 sites) of the sampled damage sites were associated with culverts (22% representing stream culverts, and 7% representing relief culverts). Eighty-one percent of the stream culvert problems caused significant environmental damage (Toth 1991). Culverts, as with any structure, have an average or expected life expectancy. As expected, the rate of failure for culverts during this storm event increased with the age of the culvert. Failure of older culverts was further exacerbated by poorer road construction standards at the time of installation. These same concerns are applicable to culverts elsewhere within the watershed. Culverts should be regularly maintained and assessed to ensure that they do not become fish passage barriers or create potential for failures that will affect fish production areas downstream.

Action Recommendation – The following salmonid habitat restoration actions are recommended:

- prioritize and correct known fish passage barriers, and assess culverts on private land, particularly in the upper watershed,

- develop a comprehensive culvert maintenance program and plan for replacement of culverts approaching or past their life expectancy, to avoid the significant environmental resource damage associated with culvert or fill failures,

- assess culverts on private land, particularly in the upper Deschutes River watershed, to identify those that are contributing to erosion, sedimentation, mass wasting, or any other environmental damage, and

- assess the current condition of the culverts and estimated life expectancy.

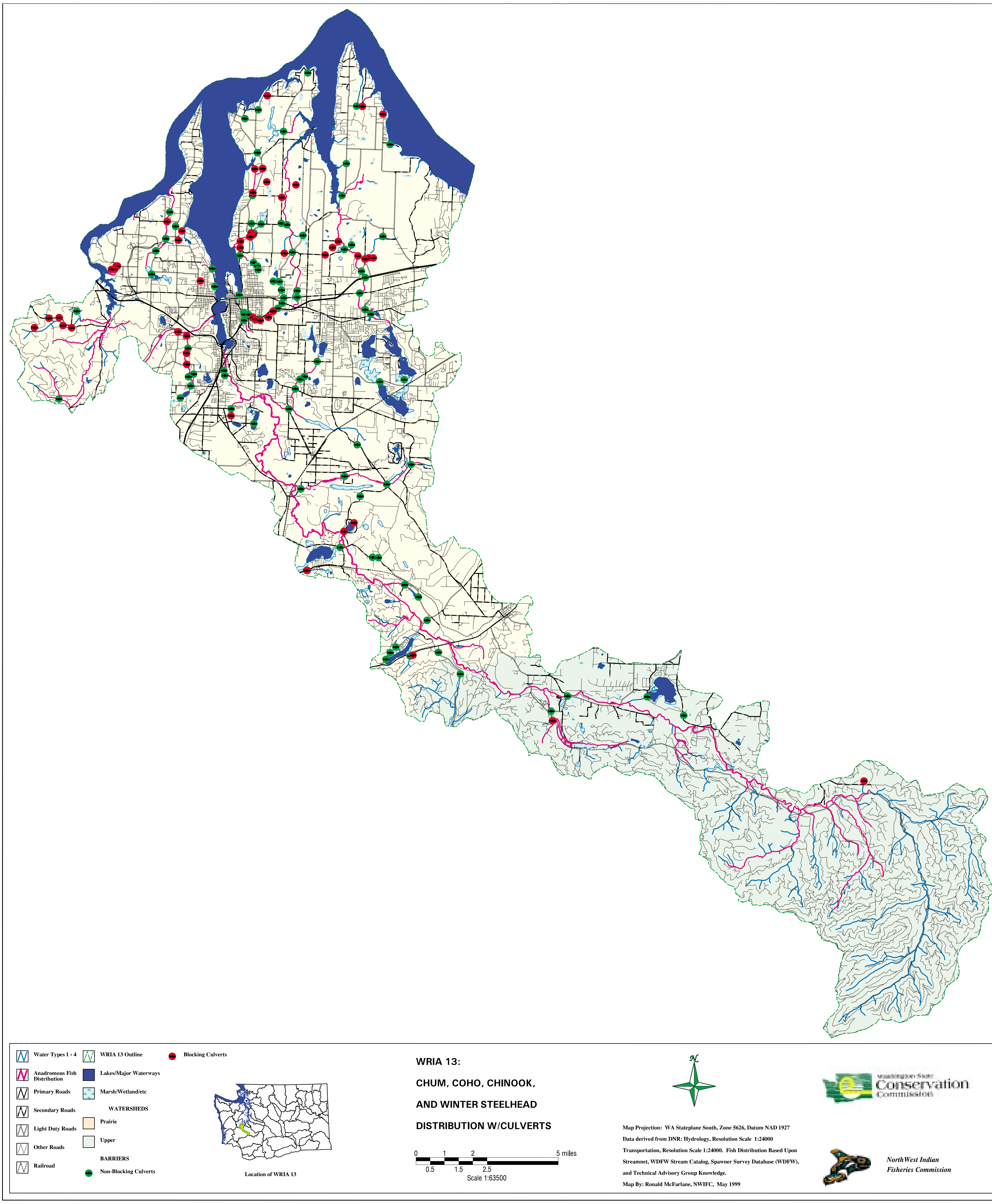

Figure 8: Inventoried culverts in WRIA 13, including tose identified both as fishpassage barries and those that were not barriers at the time the inventory was conducted.

Table 8: WRIA 13 Inventoried Culverts (Source WDFW Fish Passage Barrier Database, SSHEAR, 1999)

SITEID	SEQ	STREAM	WRIA	EAST	NORTH	ROADNAME	BARRIER
2851	1.2		13	1425883.	596670.8	STEDMAN RD SE	No
1995	1.1		13	1438286.	573626.3	MILITARY RD SE	No
2081	1.1		13	1429502.	617939.4	MULLEN RD SE	No
2122	1.1	Broyles Cr.	13	1369980.	614712.4	NORTHILL DR SW	No
259	1.1		13	1406805.	660461.3	BOSTON HARBOR RD	No
2591	1.1		13	1415245.	645102.5	SOUTH BAY RD NE	No
2608	1.2		13	1431410.	662002.4	SANDY POINT RD NE	No
2608	2.2		13	1431410.	662002.4	SANDY POINT RD NE	No
3221	1.1		13	1436687.	577959.9	WALDRICK RD SE	No
2734	2.2	Silver Cr.	13	1434134.	580216.3	SILVER CREEK DR SE	No
1988	1.1		13	1430688.	566384.7	MILITARY RD SE	No
2851	2.2		13	1425883.	596670.8	STEDMAN RD SE	No
3128	1.1		13	1461293.	556770.0	VAIL LP SE	No
3129	1.1		13	1464331.	559569.1	VAIL LP SE	No
3211	1.2		13	1422159.	587156.5	WALDRICK RD SE	No
3211	2.2		13	1422159.	587156.5	WALDRICK RD SE	No
3215	1.1		13	1428165.	585323.9	WALDRICK RD SE	No
3217	1.1		13	1429248.	585269.7	WALDRICK RD SE	No
2734	1.2	Silver Cr.	13	1434134.	580216.3	SILVER CREEK DR SE	No
1087	2.2		13	1379956.	656811.0	GRAVELLY BEACH RD	No
10218	1.1	Schneider Cr.	13	1398425.	638939.4	WEST BAY DR	No
10219	1.1		13	1398873.	635601.1		No
10308	1.1		13	1394962.	619346.7		No
10309	1.1		13	1392512.	614912.4		No
10310	1.1		13	1400745.	619087.3		No
10311	1.1		13	1400576.	619998.5		No
10312	1.1		13	1406146.	610144.9		No
1991	1.1		13	1432488.	568668.0	MILITARY RD SE	No
1087	1.2		13	1379956.	656811.0	GRAVELLY BEACH RD	No

SITEID	SEQ	STREAM	WRIA	EAST	NORTH	ROADNAME	BARRIER
1990	1.1		13	1431444.	567618.7	MILITARY RD SE	No
1481	1.1		13	1444464.	563673.2	JOHNSON CREEK RD SE	No
1488	1.1		13	1422490.	652497.1	JOHNSON POINT RD NE	No
1538	1.2		13	1387167.	637899.4	KAISER RD NW	No
1538	2.2		13	1387167.	637899.4	KAISER RD NW	No
10	1.1		13	1434042.	618316.6	AFFLERBAUGH DR SE	No
1650	1.1		13	1485902.	555965.9	LAWRENCE LAKE RD	No
1676	1.1		13	1411217.	647347.6	LIBBY RD NE	No
1690	1.1		13	1411650.	664408.1	LIBBY RD NE	No
10314	1.1		13	1401931.	612902.5		No
3838	1.1		13	1405692.	647301.3	36TH AVE NE	No
3314	1.1		13	1414691.	618383.0	WILDERNESS DR SE	No
10058	1.1	Unnamed	13	1425323.	606228.4		No
10073	1.1	Unnamed	13	1435145.	567006.2	153RD AVE SE	No
353	1.2	Lake Lois	13	1426788.	631312.0	CARPENTER RD SE	No
4074	1.1		13	1406943.	668413.1	76TH AVE NE	No
4056	1.1		13	1404479.	666790.0	73RD AVE NE	No
3820	1.1	Unnamed	13	1430082.	644904.0	32ND CT NE	No
510	1.1		13	1391619.	646780.6	COOPER PT RD NW	No
10021	1.1	Unnamed	13	1425203.	669111.0	78TH	No
10022	1.1		13	1423297.	658437.3		No
10086	1.1	Unnamed	13	1384778.	661124.7	61ST ST NW	No
4082	1.1	Unnamed	13.0000x	1430089.	667620.4	76TH AVE NE	Yes
10230	1.1	Unnamed	13.0000x	1403588.	642823.6	BOSTON HARBOR RD	Yes
4093	1.1	Unnamed	13.0001	1426283.	669054.3	78TH AVE NE	Yes
2271	2.2	Woodland Cr.	13.0006	1427842.	630470.8	PACIFIC AVE SE	No
2271	1.2	Woodland Kr	13.0006	1427842.	630470.8	PACIFIC AVE SE	No
990487	1.2	Woodland Cr.	13.0006	1426814.	637268.5	I-5	No
709	1.1	Woodland Cr.	13.0006	1426096.	638458.7	DRAHAM ST NE	No
990487	2.2	Woodland Cr.	13.0006	1426814.	637268.5	I-5	No

SITEID	SEQ	STREAM	WRIA	EAST	NORTH	ROADNAME	BARRIER
10094	1.1	Woodland Cr.	13.0006	1422945.	642512.6	PLEASANT GLADE RD. NE	No
10095	1.1	Woodland Cr.	13.0006	1422943.	642495.8	PLEASANT GLADE RD. NE	No
10100	1.1	Woodland Kr	13.0006	1425795.	634380.6		No
353	2.2	Lake Lois	13.0006	1426788.	631312.0	CARPENTER RD SE	No
3767	1.1	Jorgenson Cr.	13.0008	1419376.	641466.4	26TH AVE NE	Yes
13.0008	1.1	Jorgenson Cr.	13.0008	1421814.	643969.2		Yes
13.0008	1.2	Jorgenson Cr.	13.0008	1420738.	642861.0		Yes
13.0008	2.2	Jorgenson Cr.	13.0008	1420738.	642861.0		Yes
10096	1.1	Fox Cr.	13.0009	1424264.	643341.9	PLEASANT GLADE RD. NE	No
355	2.2	Eagle Cr.	13.0010	1426774.	640705.2	CARPENTER RD NE	Yes
355	1.2	Eagle Cr.	13.0010	1426774.	640705.2	CARPENTER RD NE	Yes
13.0010	1.1	Eagle Cr.	13.0010	1428294.	640920.7		Yes
13.0010	1.1	Eagle Cr.	13.0010	1425450.	641299.9		Yes
13.0010A	1.1	Unnamed	13.0010A	1427493.	640955.2		Yes
3850	1.1	Woodard Cr.	13.0012	1412272.	647071.1	36TH AVE NE	No
10201	1.1	Woodard Cr.	13.0012	1414151.	634829.1		No
10202	1.1	Woodard Cr.	13.0012	1414167.	634838.8		No
10203	1.1	Woodard Cr.	13.0012	1414159.	633603.9		No
2590	1.1	Woodard Cr.	13.0012	1413302.	641970.4	SOUTH BAY RD NE	No
1679	1.1	Unnamed	13.0012x	1411334.	652165.9	LIBBY RD NE	Yes
1665	1.1	Unnamed	13.0013x	1413950.	654479.4	LEMON RD NE	Yes
3766	1.1	Unnamed	13.0013x	1411802.	641784.0	26TH AVE NE	Yes
866	1.1	Unnamed	13.0015x	1416142.	675276.1	FISHTRAP LP NE	No
4115	1.1	Unnamed	13.0016x	1408647.	671035.0	81ST AVE NE	Yes
10090	1.1	Unnamed	13.0018	1405959.	653050.4	47TH AVE NE	Yes
13.0018	1.1	Unnamed	13.0018	1406310.	657436.0	PRIVATE	Yes
10089	1.1	Unnamed	13.0018	1405892.	652500.0	Boston Harbor Rd NE	No
256	1.2	Adams Cr.	13.0021	1407782.	657551.9	BOSTON HARBOR RD	Yes
13.0021	1.1	Adams Cr.	13.0021	1408543.	655030.2	PRIVATE	Yes
256	2.2	Adams Cr.	13.0021	1407782.	657551.9	BOSTON HARBOR RD	Yes

SITEID	SEQ	STREAM	WRIA	EAST	NORTH	ROADNAME	BARRIER
1162	1.1	Ellis Cr.	13.0022	1405358.	644851.2	GULL HARBOR RD NE	Yes
3839	1.1	Ellis Cr.	13.0022	1407481.	647202.2	36TH ANE NE	No
3824	1.1	Ellis Cr.	13.0022	1406151.	645555.8	33RD AVE NE	No
13.0022	1.1	Ellis Cr.	13.0022	1406035.	645243.2	PRIVATE	Yes
10229	1.1	Ellis Cr.	13.0022	1403637.	643977.2	BOSTON HARBOR RD	Yes
13.0023	1.1	Unnamed	13.0023	1405484.	644817.2	PRIVATE	Yes
3823	1.1	Unnamed	13.0024	1405681.	645582.3	33RD AVE NE	Yes
10216	1.1	Mission Cr.	13.0025	1406791.	639407.4		No
10215	1.1	Mission Cr.	13.0025	1406085.	640061.5		No
10217	1.1	Mission Cr.	13.0025	1406917.	638706.4		No
10221	1.1	Mission Cr.	13.0025	1403519.	641352.2		No
10211	1.1	Indian Cr.	13.0026	1405145.	630404.9		No
10206	1.1	Indian Cr.	13.0026	1411372.	632484.6		No
10205	1.1	Indian Cr.	13.0026	1411670.	633504.1		No
10207	1.1	Indian Cr.	13.0026	1408831.	629901.8	FREDERICK RD NE	Yes
10210	1.1	Indian Cr.	13.0026	1407193.	629632.6	WHEELER RD NE	No
990200	1.1	Indian Cr.	13.0026	1410586.	631552.6	5	No
10208	2.2	Indian Cr.	13.0026	1404295.	630778.2		No
990199	1.1	Indian Cr.	13.0026	1405976.	629853.5	5	Yes
13.0026	1.1	Indian Cr.	13.0026	1409708.	631024.6		Yes
10208	1.2	Indian Cr.	13.0026	1404295.	630778.2		No
10204	1.1	Indian Cr.	13.0026	1409754.	636588.4		No
3528	1.1	Indian Cr.	13.0026	1410859.	636525.3	12TH AVE NE	No
13.0026	1.1	Indian Cr.	13.0026	1407334.	629308.8		Yes
13.0026	1.1	Indian Cr.	13.0026	1408859.	629931.2		Yes
13.0026	1.1	Indian Cr.	13.0026	1408854.	629932.8		Yes
13.0026	1.1	Indian Cr.	13.0026	1409709.	631018.9		Yes
13.0026	1.1	Indian Cr.	13.0026	1406457.	629498.4	CENTRAL ST.	Yes
2585	1.1	Indian Cr.	13.0026	1411270.	634946.5	SOUTH BAY RD NE	No
10213	2.2	Moxlie Cr.	13.0027	1404364.	630436.5		No

SITEID	SEQ	STREAM	WRIA	EAST	NORTH	ROADNAME	BARRIER
990292	1.1	Moxlie Cr.	13.0027	1404316.	629325.5	I-5	No
10212	1.1	Moxlie Kr	13.0027	1403419.	634051.9		No
10213	1.2	Moxlie Kr	13.0027	1404364.	630436.5		No
2848	1.1	Unnamed	13.0028x	1422869.	590116.1	STEDMAN RD SE	Yes
10307	1.1	Percival Kr	13.0029	1394010.	618858.8	48TH CT. SW	No
10302	1.1	Percival Kr	13.0029	1393936.	624129.7		No
10303	1.1	Percival Cr.	13.0029	1393649.	623209.5	CHAPPARAL RD SW	Yes
10304	1.1	Percival Cr.	13.0029	1393701.	621153.4	SAPP RD.	Yes
10306	1.1	Percival Cr.	13.0029	1393689.	626447.9	MOTTMAN RD SW	Yes
10305	1.1	Percival Cr.	13.0029	1394434.	617154.3		No
10300	2.2	Black Lk.	13.0030	1392052.	627183.2	MOTTMAN RD SW	Yes
10300	1.2	Black Lk	13.0030	1392052.	627183.2	MOTTMAN RD SW	Yes
10313	1.1	Unnamed	13.0032	1401904.	611611.2	70TH AVE SE	Yes
10200	1.1	Chambers Cr.	13.0033	1417897.	621692.8		No
2479	1.1	Chambers Cr.	13.0033	1412638.	612878.4	RICH RD SE	No
3430	1.1	Chambers Cr.	13.0033	1413834.	616610.6	YELM HWY SE	No
3286	1.1	Chambers Cr.	13.0033	1415548.	618904.0	WIGGINS RD SE	No
2477	2.2	Spurgeon Cr.	13.0037	1414856.	598017.0	RICH RD SE	No
2477	1.2	Spurgeon Cr.	13.0037	1414856.	598017.0	RICH RD SE	No
2433	2.2	Spurgeon Cr.	13.0037	1430803.	598892.1	RAINIER RD SE	No
2433	1.2	Spurgeon Cr.	13.0037	1430803.	598892.1	RAINIER RD SE	No
1645	1.2	Spurgeon Cr.	13.0037	1422984.	600377.7	LATIGO ST SE	No
1645	2.2	Spurgeon Cr.	13.0037	1422984.	600377.7	LATIGO ST SE	No
10027	1.1	Spurgeon Cr.	13.0037	1435315.	602546.6		No
13.0039A	1.1	Unnamed	13.0039A	1422882.	590163.0	STEDMAN RD. SE	Yes
2994	1.1	Unnamed	13.0039x	1424731.	591733.8	TEMPO LAKE DR SE	Yes
2190	1.1	Unnamed	13.0040	1416070.	582892.2	OFFUT LAKE RD SE	Yes
10072	1.1	Unnamed	13.0045x	1435665.	567146.6	153RD AVE SE	Yes
1484	1.1	Unnamed	13.0045x	1440385.	567671.9	JOHNSON CR. RD. SE	No
435	1.1	Unnamed	13.0047	1461552.	554972.5	CHATWOOD RD SE	Yes

SITEID	SEQ	STREAM	WRIA	EAST	NORTH	ROADNAME	BARRIER
10092	1.1	Lk Lawrence	13.0050	1479130.	559430.0	PLEASANT BEACH RD	No
170	1.1	Unnamed	13.0104	1519352.	543796.0	BALD HILL RD SE	Yes
10220	1.1	Schneider Cr.	13.0131	1396222.	636637.8	BOWMAN ST NW	Yes
3262	1.1	Unnamed	13.0132	1392139.	644207.9	WESTWOOD DR NW	Yes
903	1.1	Unnamed	13.0132	1392790.	645912.9	FRENCH RD NW	Yes
1552	1.2	Green Cove Cr.	13.0133	1389803.	644491.2	KAISER RD NW	No
10093	1.1	Green Cove Cr.	13.0133	1390532.	649440.5	COUNTRY CLUB DR.	No
3835	1.2	Green Cove Cr.	13.0133	1390040.	647656.1	36TH AVE NW	Yes
3835	2.2	Green Cove Kr	13.0133	1390040.	647656.1	36TH AVE NW	Yes
1542	1.2	Green Cove Kr	13.0133	1387959.	642228.5	KAISER RD NW	No
1542	2.2	Green Cove Cr.	13.0133	1387959.	642228.5	KAISER RD NW	No
1552	2.2	Green Cove Cr.	13.0133	1389803.	644491.2	KAISER RD NW	No
3687	1.1	Unnamed	13.0137	1380620.	639433.0	17TH AVE NW	Yes
1296	1.1	Unnamed	13.0137	1379748.	638785.0	HOUSTON DR NW	Yes
2088	1.1	Swift Cr.	13.0139	1370737.	628352.8	MUNSON RD SW	Yes
13.0139	1.1	Swift Cr.	13.0139	1365437.	627969.4		Yes
413	1.2	Swift Cr.	13.0139	1372338.	627937.2	CEDAR FLATS RD SW	Yes
413	2.2	Swift Cr.	13.0139	1372338.	627937.2	CEDAR FLATS RD SW	Yes
13.0139 Z	1.1	Unnamed	13.0139 Z			PRIVATE	Yes
13.0139A	1.1	Unnamed	13.0139A			PRIVATE	Yes
410	1.1	Unnamed	13.0139x	1368173.	629711.1	CEDAR FLATS RD SW	Yes
411	1.1	Unnamed	13.0139x	1370027.	629837.4	CEDAR FLATS RD SW	Yes
310	1.1		13/14	1373275.	631021.5	CANNING CT SW	No

Table 9: WRIA 13 culvert fish passage barriers (Source WDFW Fish Passage Barrier Database, SSHEAR, 1999, revised to remove duplicates)

SITEID	SEQ	STREAM	WRIA	EAST	NORTH	ROADNAME	PI TOTAL
10230	1.1	Unamed	13.0000x	1403588.	642823.6	BOSTON HARBOR RD	
4082	1.1	Unnamed	13.0000x	1430089.	667620.4	76TH AVE NE	
4093	1.1	Unnamed	13.0001	1426283.	669054.3	78TH AVE NE	
13.0008	1.1	Jorgenson Cr.	13.0008	1421814.	643969.2		
13.0008	1.2	Jorgenson Cr.	13.0008	1420738.	642861.0		
13.0008	2.2	Jorgenson Cr.	13.0008	1420738.	642861.0		
3767	1.1	Jorgenson Cr.	13.0008	1419376.	641466.4	26TH AVE NE	
13.0010	1.1	Eagle Cr.	13.0010	1425450.	641299.9		
355	1.2	Eagle Cr.	13.0010	1426774.	640705.2	CARPENTER RD NE	12.1466
355	2.2	Eagle Cr.	13.0010	1426774.	640705.2	CARPENTER RD NE	12.1466
13.0010	1.1	Eagle Cr.	13.0010	1428294.	640920.7		
13.0010A	1.1	Unnamed	13.0010A	1427493.	640955.2		
1679	1.1	Unnamed	13.0012x	1411334.	652165.9	LIBBY RD NE	
3766	1.1	Unnamed	13.0013x	1411802.	641784.0	26TH AVE NE	6.4957
1665	1.1	Unnamed	13.0013x	1413950.	654479.4	LEMON RD NE	23.1994
4115	1.1	Unnamed	13.0016x	1408647.	671035.0	81ST AVE NE	
13.0018	1.1	Unnamed	13.0018	1406310.	657436.0	PRIVATE	
10090	1.1	Unnamed	13.0018	1405959.	653050.4	47TH AVE NE	12.9150
13.0021	1.1	Adams Cr.	13.0021	1408543.	655030.2	PRIVATE	
256	2.2	Adams Cr.	13.0021	1407782.	657551.9	BOSTON HARBOR RD	16.0047
256	1.2	Adams Cr.	13.0021	1407782.	657551.9	BOSTON HARBOR RD	16.0047
13.0022	1.1	Ellis Cr.	13.0022	1406035.	645243.2	PRIVATE	
10229	1.1	Ellis Cr.	13.0022	1403637.	643977.2	BOSTON HARBOR RD	23.8487
1162	1.1	Ellis Cr.	13.0022	1405358.	644851.2	GULL HARBOR RD NE	23.8216
13.0023	1.1	Unnamed	13.0023	1405484.	644817.2	PRIVATE	
3823	1.1	Unnamed	13.0024	1405681.	645582.3	33RD AVE NE	21.6473
10207	1.1	Indian Cr.	13.0026	1408831.	629901.8	FREDERICK RD NE	12.6995
13.0026	1.1	Indian Cr.	13.0026	1406457.	629498.4	CENTRAL ST.	
13.0026	1.1	Indian Cr.	13.0026	1407334.	629308.8		
13.0026	1.1	Indian Cr.	13.0026	1408859.	629931.2		
13.0026	1.1	Indian Cr.	13.0026	1408854.	629932.8		
13.0026	1.1	Indian Cr.	13.0026	1409709.	631018.9		
990199	1.1	Indian Cr.	13.0026	1405976.	629853.5	I-5	18.4465
13.0026	1.1	Indian Cr.	13.0026	1409708.	631024.6		
2848	1.1	Unnamed	13.0028x	1422869.	590116.1	STEDMAN RD SE	22.2295

10303	1.1	Percival Cr.	13.0029	1393649.	623209.5	CHAPPARAL RD SW	32.4078
10304	1.1	Percival Cr.	13.0029	1393701.	621153.4	SAPP RD.	32.1919
10306	1.1	Percival Cr.	13.0029	1393689.	626447.9	MOTTMAN RD SW	
10300	2.2	Black Lk	13.0030	1392052.	627183.2	MOTTMAN RD SW	37.4413
10300	1.2	Black Lk	13.0030	1392052.	627183.2	MOTTMAN RD SW	37.4413
10313	1.1	Unnamed	13.0032	1401904.	611611.2	70TH AVE SE	
13.0039A	1.1	Unnamed	13.0039A	1422882.	590163.0	STEDMAN RD. SE	
2994	1.1	Unnamed	13.0039x	1424731.	591733.8	TEMPO LAKE DR SE	
2190	1.1	Unnamed	13.0040	1416070.	582892.2	OFFUT LAKE RD SE	9.5218
10072	1.1	Unnamed	13.0045x	1435665.	567146.6	153RD AVE SE	
435	1.1	Unnamed	13.0047	1461552.	554972.5	CHATWOOD RD SE	
170	1.1	Unnamed	13.0104	1519352.	543796.0	BALD HILL RD SE	8.3866
10220	1.1	Schneider Cr.	13.0131	1396222.	636637.8	BOWMAN ST NW	
3262	1.1	Unnamed	13.0132	1392139.	644207.9	WESTWOOD DR NW	
903	1.1	Unnamed	13.0132	1392790.	645912.9	FRENCH RD NW	10.9670
3835	2.2	Green Cove Cr13.0133		1390040.	647656.1	36TH AVE NW	
3835	1.2	Green Cove Cr.	13.0133	1390040.	647656.1	36TH AVE NW	
1296	1.1	Unnamed	13.0137	1379748.	638785.0	HOUSTON DR NW	17.1014
3687	1.1	Unnamed	13.0137	1380620.	639433.0	17TH AVE NW	12.0760
13.0139	1.1	Swift Cr.	13.0139	1365437.	627969.4		
413	1.2	Swift Cr.	13.0139	1372338.	627937.2	CEDAR FLATS RD SW	7.3174
413	2.2	Swift Cr.	13.0139	1372338.	627937.2	CEDAR FLATS RD SW	7.3174
2088	1.1	Swift Cr.	13.0139	1370737.	628352.8	MUNSON RD SW	8.3155
13.0139 Z	1.1	Unnamed	13.0139 Z			PRIVATE	
13.0139A	1.1	Unnamed	13.0139A			PRIVATE	
410	1.1	Unnamed	13.0139x	1368173.	629711.1	CEDAR FLATS RD SW	5.1084
411	1.1	Unnamed	13.0139x	1370027.	629837.4	CEDAR FLATS RD SW	

Table 10: Road drainage characteristics that drain directly to channels of various orders in the Deschutes basin based on the existing road network in 1980 (Source: Sullivan et al., 1987)

				Direct Entry Culverts						
				Orders 3-4		Order 2		Order 1		
Stream	Total Road Length	No. of Culvert	% DE	Number	Length (m)	Number	Length (m)	Number	Length (m)	Ratio of Road Length to Stream Length (m/m)
Mitchell	53.6	064	33	2	869	3	919	15	3,543	0.06
Johnson	24.1	44	43	5	2,000	7	2,165	8	1,722	0.20
Thurston	38.9	143	41	2	820	10	2,469	45	9,457	0.20
Huckleberry	20.3	39	44	2	787	2	492	12	2,707	0.14
Lewis	13.2	47	47	4	902	6	1,280	12	3,478	0.45
Lincoln	42.5	153	48	2	410	7	1,919	63	12,115	0.22
Little Deschutes	73.2	193	15	6	705	8	230	14	2,457	0.05
Buck	9.5	35	23	0	-	0	-	8	1,230	0.00
Westfork	9.6	22	50	1	328	2	705	8	1,542	0.08
Ware	6.3	3	67	1	82	0	-	1	328	0.03
Hard	4.7	3	33	1	459	0	-	0	-	0.18
Mine	4.5	17	47	0	-	4	1,214	4	673	0.35
*3000 Road	-	205	38	13	3,658	12	3,281	49	11,360	-
Total Deschutes Basin (upper basin only)	511.0	1,097	33	51	14,936	70	17,077	270	50,612	0.19

*The 3000 road is the main trunk of the road network that follows the river for most of its length in the upper watershed.

Substrate

Channel sediments present in an ecologically healthy stream channel are naturally dynamic and are a function of a number of processes which input, store, and transport the materials. Processes vary spatially and temporally and depend upon a number of features of the landscape, such as stream size, gradient, basin size, geomorphic context, and hydrologic regime. In forested mountain basins, sediment enters stream channels from mass wasting (landslides and debris flows), surface erosion, and soil creep. Inputs of major pulses of sediment to a stream channel in these types of basins usually occurs periodically during extreme events, such as floods and mass wasting, which are the result of climatic events. In lowland streams, surface and bank erosion are the major sediment sources. Input of sediment in these basins tends to be more steady over time.

Once sediment enters a stream channel, it can either be stored or transported depending upon particle size, stream gradient, hydrologic conditions, availability of storage sites, and channel form (e.g., amount of LWD). Finer sediments tend to be transported through the system as wash load or suspended load, with little effect on channel morphology. Coarser sediments (>2 MM diameter) tend to travel as bedload and so can have larger effects on channel morphology as they move downstream through the channel network. Fine sediments (<0.85 mm) tend to clog substrate gravels, impairing the ability of flow to penetrate the gravels, and reducing survival of salmon eggs. Percentages of fine sediment exceeding 12% are known to adversely impact salmonids.

Human actions result in increase or decrease in the supply of sediments to a stream. Increases in sediment result from the isolation of a channel from the associated floodplain by development of lowland areas, which eliminates important storage areas for sediment. In addition, actions that destabilize the landscape in high slope areas, such as logging or road construction, increase the frequency and magnitude of flood flows, increasing the rate of erosion. Increases in the proportion of fine sediment in the bed can reduce the survival of incubating eggs in the gravel and change benthic invertebrate production, on which salmonids prey.

In addition to affecting supply, human activities can also affect the storage and movement of sediment in a stream. Isolation of stream from the floodplain, increases in sediment supply, or increased frequency and magnitude of flood flows moves larger and greater amounts of sediment more frequently. This can increase bed scour and aggradation, bank erosion, and alter channel morphology, ultimately degrading the quality of spawning and rearing habitat.

Substrate sampling data for fine sediment are limited in WRIA 13, although several assessments of substrate condition have been done for segments of the mainstem Deschutes River and its major tributaries upstream of Vail that are within the anadromous zone. These include Schuett-Hames and Flores (1994), Schuett-Hames and Child (1996), both of which used Timber/Fish/Wildlife (TFW) monitoring protocols and McNeil samplers, and Cramer (1997) which was based on pebble counts.

The Squaxin Island Tribe evaluated substrate composition in six reaches of the Deschutes River, one reach in Mitchell Cr., two reaches in Huckleberry Cr., one reach in Johnson Cr., and one reach in Thurston Cr. (Schuett-Hames and Flores, 1994). Within each reach, samples were taken at several riffles using a McNeil sampler. The percent fines less than 0.85 mm were evaluated, due to the adverse impacts of fine sediment on salmon egg incubation. The data were compared to the TFW Watershed Analysis rating system, where fine sediment <12% is good (high survival predicted), 12-17% is fair (moderate and variable survival predicted), and >17% is poor (low survival predicted). The summary of data collected from this study is presented in Table 11. Of the eleven reaches evaluated, three were rated as good, six were rated as fair and two were rated as poor. In some cases, elevated fine sediment levels were found downstream of large landslide deposits. At least one of the reaches that was rated as good did not have any suitable spawning gravels because the bed was scoured down to cobble, boulders, and bedrock. Generally the Deschutes system above Vail was characterized as not providing good spawning conditions for salmonids due to elevated fine sediment levels and streambed instability (gravel scouring).

Table 11: Spawning gravel fine sediment levels and Watershed Analysis rating for the Deschutes River system (from Schuett-Hames and Flores, 1994)

Stream	Gradient (%)	Avg. % fines <0.85 mm	Std. Dev.	Watershed Analysis Rating
Deschutes, Seg. 16	0.6	13.1	5.1	FAIR
Deschutes, Seg. 17	0.55	13.5	9.5	FAIR
Deschutes, Seg. 18	0.53	12.1	4.1	FAIR
Deschutes, Seg. 19	0.43	11.6	3.5	GOOD
Deschutes, Seg. 20	0.15	12.9	4.7	FAIR
Deschutes, Seg. 22	0.25	18.2	3.7	POOR
Mitchell, Seg. 1	2.0	9.6	4.0	GOOD
Huckleberry, Seg. 1	2.0	20.0	5.9	POOR
Huckleberry, Seg. 2	2.22	16.1	10.6	FAIR
Johnson, Seg. 1	1.94	13.4	5.4	FAIR
Thurston, Seg. 1	2.0	11.1	6.9	GOOD

In a separate study, the Squaxin Island Tribe evaluated substrate composition in five reaches of the mainstem Deschutes River (Schuett-Hames and Child, 1996), one in the lower river (segment 36), two in the middle portion of the river (segments 31 and 28), and two upstream of Vail (segments 22 and 19). Sampling was done using TFW Monitoring protocols and a McNeil sampler. The data were also compared to the TFW Watershed Analysis rating system identified above. Summary data from this study are presented in Table 12. Of the five reaches, none rated good, one rated fair, and four rated as poor. These results indicate that spawning suitability appears to be compromised throughout the mainstem Deschutes River by elevated presence of fine sediments (>12%) in the substrate. Fine sediments have been documented in the literature to reduce survival to emergence.

Table 12: Spawning gravel fine sediment levels (<0.85 mm) and Watershed Analysis resource ratings for the Deschutes River, 1995 (from Schuett-Hames and Child 1996)

River	Seg. No.	River Mile	Gradient (%)	Avg. % fines <0.85 mm	Std. Dev.	Watershed Analysis Rating
Deschutes	19	33-35.7	0.40	15.5	4.5	FAIR
Deschutes	22	28.5-29.5	0.18	22.5	6.1	POOR
Deschutes	28	20.8-22.0	1.10	19.4	4.9	POOR
Deschutes	31	15.0-17.5	0.30	19.9	4.9	POOR
Deschutes	36	2.5-4.5	0.20	22.0	4.8	POOR

During the summers of 1996 and 1997, Thurston County conducted a reach scale analysis and habitat survey in the Deschutes River (Cramer, 1997) from Tumwater Falls to Deschutes Falls

(RM 41). The river was segmented into 343 reaches. Substrate sediment was evaluated in each segment using the pebble count method, following guidelines in Leopold (1970). The smallest particle size category was <4 mm. Whereas pebble count data is pertinent to the presence/availability of spawning gravels, it is not possible to draw conclusions regarding the impact of fine sediment (<0.85 mm) where spawning size gravels are identified.

In 1993-1994, the Squaxin Island Tribe conducted an assessment of salmonid habitat in streams entering Eld Inlet and other inlets in south Puget Sound (Schuett-Hames et al., 1996). Of specific relevance to WRIA 13, segments in McLane and Swift creeks were included in this study effort, using a McNeil sampler and TFW Monitoring protocols. Both samples (McLane 16.8%, Swift 14.4%) were rated as fair using the Watershed Analysis rating system for fine sediment.

In addition to the culvert data included in the WDFW Fish Barrier Database, there is some information on the relationship of culverts and sediment in the forest management zone of the upper Deschutes watershed. A Weyerhaeuser report (Sullivan et al. 1987) identifies 1,097 culverts in the upper Deschutes watershed (1980 existing road network), including tributaries (Table 10) Of these, 391 (33%) had direct entry to streams. Most (88%) of these culverts were reported to drain directly to Type 4 or 5 streams. [NOTE: Stream typing criteria are identified in the Washington Forest Practice Rules and Regulations. Although Type 4 and 5 streams are considered to not be fish bearing, it has been found that a significant percentage of streams designated as Type 4 or 5 directly support salmonids. Even those where salmonids are not present provide indirect support for salmonids downstream.] The drainage length encased in the 391 culverts draining directly to streams is 82,627 m. (51.6 miles). Because sediment often is either absent or impaired within culverts, this represents a significant loss of benthic invertebrate production in the upper watershed. The sampling conducted by Toth (1990), subsequent to the January 1990 floods, included sites where the blockage of culverts with debris resulted in failure of the road fill and contribution of the slide material to the stream below. It also included road associated landslides. There was no estimate of total volume of slide input to upper Deschutes River tributaries, because the work by Toth was based on only a subsample of damage sites chosen by the road engineer.

Sullivan et al. (1987) suggest a general relationship between road-use and increased turbidity in tributaries of the Deschutes River, but no quantitative relationship based on traffic rate could be established. Perhaps the single most important characteristic which determines the extent to which truck traffic affects water quality is the amount of road surface in a basin which drains directly to streams. Road densities for the Deschutes watershed upstream of the 1000 Road including tributaries are presented in Table 13. Turbidity also differed between watersheds as a function of differences in geology and from year to year as a function of rainfall (Sullivan et al. 1987). However, turbidity can be significantly affected by specific discharge points in proximity to the channel, even though the overall road network may be low (McGreer and Heffner 1978, as reported in Sullivan et al. 1987). Bilby (1985) also documented the significant effect that one particular discharge point can have on sediment loading of a stream. He found that a single culvert in Johnson Creek which drains an unusually large amount of road surface directly to the stream contributed 21% of the total annual sediment load of the subbasin (Sullivan et al. 1987). Reid (1981) concluded that gravel-based forest roads resulted in increased total sediment production, and that forest road surface erosion is the most important source of sediment <2 mm in diameter. She found that presence of 2.5 km/km^2 of graveled forest roads undergoing a typical road-use distribution in an otherwise undisturbed basin would increase sediment production by a factor of 3.4-4.9. All but one of the subbasins in the upper Deschutes (Table 13) had significantly higher road densities in 1980 than those evaluated by Reid (1981), with additional road construction since. The forest road network in the upper Deschutes has the potential to be contributing significantly elevated rates of sediment, particularly fine sediment <2 mm, to the basin. Fine sediment is identified as one of the key limiting factors in WRIA 13 streams that have been sampled, and is also readily apparent in many of the upper Deschutes tributaries (personal observation). Because fine sediment is easily distributed throughout the watershed, efforts should be made to avoid additional fine sediment contribution to areas that are already adversely impacted by fine sediment load.

Table 13: Road density in the Deschutes basin above the 1000 Road and in tributary basins (Source – Sullivan et al. 1987, reflects road network through 1986)

Basin	Road Density (km/km^2)
Total Deschutes Basin	3.7
Mitchell Cr.	2.4
Huckleberry Cr.	4.4
Johnson Cr.	4.4
Thurston Cr.	3.3
Little Deschutes	4.0
Lincoln Cr.	4.2
Lewis Cr.	4.5
Buck Cr.	4.6
Westfork	3.6
Ware	3.0
Hard Cr.	4.7
Mine Cr.	3.5

Specific knowledge of potential impacts from fine sediment in spawning gravels is limited to those few stream segments in the WRIA where sampling has been done. Available sampling data indicates that fine sediment is of concern in most of the sampled stream segments, and is identified as one of the key limiting factors in the Deschutes River, and in McLane and Swift creeks. Substrate characterization sampling would also be of benefit for the other streams in WRIA 13.

The Thurston Conservation District has completed nine streambank bioengineering projects to control bank erosion, including fine sediment. The young, glacial origin of the watershed naturally produces high sediment loads in the streams. The bioengineering projects are not expected to make any measurable decrease in the rate of fine sediment input into Capitol Lake.

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- further evaluate the sediment contribution rate from the upper watershed, particularly in recognition of the significant number of slides and road failures that resulted from the January, 1990 floods,
- conduct substrate sampling in additional streams and stream segments to determine to what extent fine sediment in spawning gravels may be a limiting factor elsewhere in WRIA 13, and
- reestablish mature riparian buffers of sufficient width to slow the rate of lateral erosion of the channel; maintain functional riparian buffers throughout the channel migration zone.

Floodplains

Floodplains are portions of a watershed that are periodically flooded by the lateral overflow of rivers and streams. Most floodplain areas are located in lowland areas of river basins and are associated with larger mainstem streams. Floodplains are typically structurally complex and are characterized by a great deal of lateral, aquatic connectivity by way of sloughs, backwaters side channels, oxbows, and lakes. Often floodplain channels can be highly braided (multiple parallel channels).

Floodplains function as important aquatic habitat for some species and life stages such as coho salmon juveniles that often use the sloughs and backwaters of floodplains to overwinter, seeking refuge from high flow events. Floodplains also help dissipate water energy during floods by allowing water to escape the channel and inundate the terrestrial landscape. Floodplains also provide coarse beds of alluvial sediments through which subsurface flow passes, maintaining high water quality by filtering nutrients and other chemicals.

There are two major types of human impacts to floodplain functions:

- disconnection of channels from their floodplains, both laterally as a result of construction of dikes and levees, and longitudinally as a result of construction of road crossings,
- loss of natural riparian and upland vegetation, which affect the in-channel habitat characteristics and increase energy of flood flows.

Elimination of off-channel habitats can result in loss of important rearing habitats for juvenile salmonids, such as sloughs and backwaters that function as overwintering habitat for coho juveniles. Disconnection of stream channels from their floodplain due to levee and dike construction increases water velocities, which in turn increases scour of the streambed, with potential for increased mortality of salmon eggs.

Most of the Deschutes River below Deschutes Falls (RM 41.0) flows through unconsolidated silt, sand, and gravel deposited by the last continental glaciation. Consequently, the watershed is only about 12,000 years old and is still in the process of building its floodplain by undercutting glacial terraces that exist throughout the middle and lower basin. Upstream of Deschutes Falls (RM 41) the river flows through primarily weathered volcanic rock with steep straight slopes focused into narrow V-shaped valleys (Collins 1994).

Floodplain Constrictions

Dikes, levees, and other floodplain constrictions were not identified as a habitat limiting factor or concern in WRIA 13. There are numerous stream banks where bank hardening/armoring inhibit the ability of the channel to move, and adversely impact salmonid habitat, but no sites were identified that prohibit flood flow access to the floodplain. The floodplain and channel meander zones have been mapped and are included in Appendix 2 of this report.

The lack of off-channel habitat on the Deschutes River is identified as a habitat factor limiting salmonid productivity, particularly for coho. Cramer (1997) found that 72% of the 343 reaches surveyed had little or no off-channel rearing availability, 17% of the reaches ranked medium, and only 11% ranked high. Off-channel habitat is essential to the life history of several salmonid species, providing stable habitat for spawning and rearing, and providing refuge for adult and juvenile salmonids during peak flows. Historically, off-channel habitat in the Deschutes is thought to have been more prevalent. Subsequent to the Reach Scale Analysis (Cramer 1997), the Squaxin Tribe has mapped off-channel habitat areas and is in the process of prioritizing them for protection and restoration funding. Mapped off-channel habitats are identified on the floodplain maps in Appendix 2. It is recommended that existing off-channel habitat information be supplemented with additional field surveys, concentrating first on the area between Offut Lake and Lake Lawrence.

Action Recommendation – The following salmonid habitat restoration actions are recommended:

- minimize the amount of bank armoring, allowing the channel to move within the channel migration zone, and
- restore off-channel habitat on the Deschutes River.

Streambank Stability

The most complete data available on streambank stability are found in the Deschutes River Reach Scale Analysis and Habitat Survey (Cramer, 1997). Active channel bank erosion was evaluated for each bank in each of 343 reaches from lower Deschutes Falls (RM 1.9) to Deschutes Falls (RM 41.0). Table 14 presents a summary of the data.

Bank erosion and channel migration have been prominant issues (property damage, flooding) in the Deschutes Basin for a number of years (Cramer, 1997). It is clear from the reach data that active bank erosion is common throughout the Deschutes mainstem. Nearly 2/3 of the river length had bank erosion exceeding 20% on at least one bank. Thirty seven percent of the reaches had bank erosion exceeding 20% on both banks. The Wild Salmonid Policy (WDFW and WWTIT 1997) identifies bank erosion rates > 10% as being detrimental to salmonids. Bank erosion >10% contributes to channel instability, substrate aggradation and scour, and elevation of fine sediment levels in the channel substrate. Even with well developed, mature riparian stands, it is thought that channel erosion would be common due to the Deschutes being a geologically "young" watershed (Cramer 1997, Collins 1994). Erosion was found on banks with and without mature riparian vegetation. Significantly eroding banks did have a higher occurrence of fine grained, unconsolidated sands and silts than the reaches with non-significant erosion. Mature riparian vegetation existed in more than 50% of the reaches where bank erosion exceeded 60%. The study did not consider the rate of erosion, only the occurrence of erosion (Cramer 1997). It is important to remember that mature riparian vegetation is important to develop and protect, since mature riparian buffers tend to slow the rate of channel migration on banks less than three meters high (>90% of banks in study area). Human modification did not correlate well with the occurrence of significantly eroding banks. However, field observation did appear to indicate a high occurrence of erosion on banks downstream of rip-rapped banks and extremely active sloughing of banks that had been cleared for pasture (Cramer 1997).

Table 14: Reach scale occurrence of active bank erosion on the Deschutes (from Cramer, 1997). Data reflects sampling of reaches from Tumwater Falls to Deschutes Falls (total of 39.1 miles)

Erosion Rate	Left Bank (miles)	Right Bank (miles)	Both Banks (miles)
>20%	28.85	24.52	14.57
>50%	21.11	16.92	5.86
>75%	15.36	12.94	2.35

The conclusions in Cramer (1997) suggest that local channel characteristics at the reach level do not appear to be the driving force causing channel erosion and migration. This agrees with

Collins (1994) findings that the dominant influences on the rates and locations of eroding banks are geologic and topographic. Mainstem channel erosion occurs more often downstream of a coarse sediment source, where the channel is not confined and gradient is declining. This is common among glaciated lowland river valleys in the Northwest. Rivers in these conditions tend to erode more sediment from their mainstem than is transported in from the headwaters as they incise and widen their floodplains into the glacial terraces (Collins 1994).

Human manipulation of banks was found to be high in the Reach Scale Analysis (Cramer 1997). This typically represents rip-rapping, artificial armoring, removal of riparian overstory, or other disturbance of natural bank characteristics. Table 15 provides summary data for Human Manipulation. Approximately one quarter of the length of each of the right and left banks has bank alteration exceeding 50% of the reach length.

Table 15: Miles of Deschutes River banks that have been altered by human manipulation (riparian removal, bank armoring, bank alteration, etc.)(Source, Cramer 1997)

Bank Manipulation Threshold	Left Bank (miles)	Right Bank (miles)	Both Banks (miles)
>20%	13.85	12.30	8.04
>50%	10.64	9.79	5.97
>75%	8.82	8.38	4.63

Slowing or stopping channel erosion of glacial terraces is probably not practical. The river will likely reclaim these terraces and widen its floodplain, which in the long run could have a stabilizing effect on the channel. Allowing the river to widen its floodplain can result in greater energy dissipation of peak flows and tends to increase habitat complexity (Cramer 1997). Traditional use of bank hardening (riprap) is not likely to be effective in the long-term, and may actually increase the rate of bank erosion downstream. In addition, bank hardening eliminates habitat features important to salmonids. Mature riparian zones should be reestablished and maintained within the channel meander zone to limit the rate of bank erosion and channel change.

Action Recommendation – The following salmonid habitat restoration actions are recommended:

- protect the integrity of the river meander zone by restoring functional mature riparian vegetation, to the outer limits of the meander zone, that will slow bank erosion (this recommendation is based specifically on Deschutes River observations, but is probably applicable WRIA wide), and
- avoid bank protection projects, such as riprap, that tend to increase the rate of bank erosion downstream.

Presence of Large Woody Debris (LWD) in Channel

Downed large woody debris (trees, logs, rootwads, log jams) are an integral element of stream ecology, creating the habitat diversity important to salmonids. The TFW Watershed Analysis Manual classifies LWD into two groups; all pieces >10 cm diameter and 2 m long qualify as LWD, key piece size LWD includes pieces of significant size to create habitat features in the channel (1.0-9.0 cubic m^3/piece depending on channel width). LWD functions in the channel to reduce stream energy, provide cover, create pools, retain gravels, and stabilize stream bed and banks. LWD presence has been adversely impacted by decay and active removal of LWD from stream channels, and by removal of mature riparian vegetation which eliminates the potential for additional LWD recruitment. Of particular concern is that mature riparian conifer vegetation is required to contribute functional key piece LWD. Current riparian condition on most streams is not capable of providing functional LWD, and even with riparian restoration will not be capable of providing key piece LWD for 50-100 years. LWD restoration will likely require both long-term recovery and an interim strategy to maintain ecological stream function.

Assessment of LWD has been done for the mainstem Deschutes River (Cramer 1997, Schuett-Hames and Child 1996) and for segments in McLane and Swift creeks (Schuett-Hames et al. 1996). Both of the studies on the mainstem Deschutes River had comparable findings. Schuett-Hames and Child (1996) assessed LWD in five mainstem segments. Using Watershed Analysis criteria, the LWD piece count was rated as good in each of the five segments, but each of the segments rated poor in relation to the presence of key piece LWD (pieces with volumes >9 m^3). Similar findings resulted from the Reach Scale Analysis (Cramer1997) which reported 59% of the reaches with >2 pieces of LWD per bankfull width (good), 30% of the reaches with 1-2 pieces of LWD per bankfull width (fair), and 12% of the reaches with <1 piece LWD per bankfull width (poor). Cramer also reported few large logs (>50 cm (20 in.) diameter). Most of the few large logs were part of debris jams. He reported the majority of woody debris (89%) in both debris jams and individual pieces consisted of small and medium sized logs. Small and medium sized logs are not very stable and probably not effective at creating habitat in the Deschutes River. Field observations during the survey appeared to concur with the findings of Bilby (1985, as referenced in Cramer 1997), that individual pieces need to be >50 cm in diameter and 10 meters in length to have stability in a channel with a bankfull width >15 meters. Cramer indicates that for an individual log to be stable and function as habitat in the Deschutes River, it would probably have to be >70-75 cm (30 in.) in diameter and 12-15 meters (40-50 ft.) in length.

Schuett-Hames et al. (1996) assessed LWD condition in a single segment on each of McLane and Swift creeks. Their findings were consistent with those on the mainstem Deschutes River. Although the total count of LWD pieces in each segment rated as good, the lack of key piece LWD rated as poor.

Available data from Deschutes River and Percival, Black Lake Ditch, Green Cove, Schneider, McLane, and Swift creeks indicate that streams in WRIA 13 are deficient in key piece LWD, which are the LWD components that tend to create stable and functional fish habitat. Unfortunately, riparian stands have been altered in many of the streams, eliminating the near-term recruitment potential for LWD, particularly key piece-sized LWD. A key finding of this analysis is that it will likely be necessary to develop an interim LWD supplementation strategy until a longer-term riparian recovery strategy results in equilibrium recruitment of LWD, particularly key piece LWD.

Action Recommendation – The following salmonid habitat restoration actions are recommended:

- restore mature conifers in the riparian zone that will contribute functional key piece LWD to the channel, and
- develop and implement an interim strategy for LWD supplementation until natural LWD recruitment is restored; evaluate whether supplementation must be accomplished throughout the system or whether priority areas can be identified.

Presence and Condition of Pools

Pools are an integral component of salmonid habitat, providing rearing habitat for juvenile salmonids, and resting and cover habitat for adults on their upstream spawning migration. Pool frequency and quality data are limited in WRIA 13. Evaluation of pools in the mainstem Deschutes River was conducted as part of the Reach Scale Analysis (Cramer 1997). However, the river was only classed into two categories – riffles and pools. The majority of identified pool habitat is thought to actually be long non-complex runs with sufficient depth that classified them as pools, but which do not provide the same habitat value as true pools. The Squaxin Island Tribe evaluated pools as one of the elements in their monitoring assessment on small segments of both McLane and Swift creeks (Schuett-Hames et al. 1996).

Data from the Deschutes River Reach Scale analysis (Cramer 1997) indicate >50% of the reaches had >55% pools at low flow (good), 17% of the reaches had 40-55% pools (fair), and 27% of the reaches had <40% pools (poor). The ratings should be used as indicators only, as no commonly accepted standards currently exist for channels with mean bank full flow >15 m wide; these are the standards currently accepted for channels <15 m wide. Pool habitat did not rank as well when considering the number of bankfull widths per pool or pool frequency. Forty–seven percent of reaches had >4 bankfull widths per pool (poor), 29% of the reaches had 2-4 bankfull widths per pool (fair), and 24% of the reaches had <2 bankfull widths per pool (good). Residual pool depth varied from 0.4 to 4.0 meters (1.3-13 ft.)(Cramer 1997). This also appears to be consistent with the lack of LWD throughout the mainstem. This condition would negate much of the rearing benefit and value, particularly for species such as coho and cutthroat, associated with typical pool habitat.

Monitoring assessment in McLane and Swift creeks (Schuett-Hames and Flores 1997) indicated pool surface area >50% in both segments (fair), and pool frequency of 2.71 and 2.39 bankfull widths per pool (fair), respectively. Mean residual pool depths were 0.39 and 0.41 meters, respectively.

Action Recommendation – The following salmonid habitat restoration actions are recommended:

- restore pool frequency and function through introduction of functional LWD (primarily conifer) to mainstem and tributary channels,
- restore and maintain functional riparian zones to reduce landslide and bank erosion that can fill pool habitat with sediment,
- restore functional mature conifers in the riparian zone that will limit bank erosion and associated in-filling of pools, and
- seek development of commonly accepted pool frequency standards for channels with mean bank full width >15m.

Riparian Buffer Width

Stream riparian zones include the area of living and dead vegetative material adjacent to a stream. They extend from the edge of the stream toward the uplands to a point where the zone ceases to have an influence on the stream channel. Riparian forest characteristics in ecologically healthy watersheds are strongly influenced by climate, channel geomorphology, and where the channel is located in the watershed. The width of the riparian zone and the extent of the riparian zone's influence on the stream are strongly related to stream size and basin morphology.

Functions of riparian zones include providing hydraulic diversity, adding structural complexity, providing a refuge from predators and extreme environmental events, buffering the energy of runoff events and erosive forces, moderating stream temperatures, and providing a source of nutrients. They are especially important as the source of LWD to streams, which directly influences several habitat attributes important to anadromous species. In particular, LWD develops pool habitat, provides sediment storage and streambed stability, and provides refuge from predators and high flow impacts. Loss of LWD results in a significant reduction in the complexity of stream channels including a decline of pool habitat, which reduces juvenile salmonid rearing capacity. Loss of LWD also affects the amount of both overwintering and low flow rearing areas.

Historic natural riparian buffers in the Deschutes River watershed, including tributaries, typically would have been a mature conifer stand, including cedar, Douglas fir, and hemlock, with understory presence of deciduous species. Riparian vegetation provides a number of functions critical to a healthy watershed, including shade, cover, improved water quality, leaf litter to help support the aquatic food chain, and large wood to the channel to provide channel complexity and key habitat niches. Unfortunately, many of these functions are significantly compromised in the Deschutes River due to the lack of functional riparian zones. Riparian vegetation has been altered over time, typically associated with the adjacent land use. Vegetation has been removed for the value of the timber, to facilitate views and access to the river, as well as providing alternate land use, such as grazing and agriculture. Riparian buffer disturbance and removal has occurred in all land use categories, urban and suburban, agriculture, and forest management.

The Wild Salmonid Policy (WDFW and WWTIT 1997) recommends a buffer of mature conifers the width of one site-potential tree height (the height of the tallest dominant or co-dominant native tree that would naturally grow on the soils present at the site) to provide the functions important to salmonids. Wide riparian buffers are important to minimize stream bank erosion, provide shade, provide cover, maintain water quality, and provide LWD to the channel. They are particularly important where the stream or river is located in a broad floodplain, to minimize the potential of major channel changes within the river meander zone. Riparian function is compromised when buffers are narrower than the functional width or where the buffer vegetation has been altered and historical conifer presence has been replaced with deciduous trees. Conifer are of particular importance because of their contribution of large wood to the stream channel, which creates the instream habitat diversity important to salmonids.

Riparian vegetation status was evaluated as part of the Deschutes River Reach Scale Analysis (Cramer, 1997). Table 16 provides summary data of length of stream banks that had riparian buffers within the designated widths. Thirty meters represents the minimum riparian buffer width at which most riparian functions would be met. Riparian buffers <10 m. typically provide minimal to no effective riparian function. Riparian distances of 10-30 m. provide partial riparian function. In addition, the type of riparian vegetation was also identified in the Cramer (1997) analysis. In general, there were few reaches where conifer presence was identified; most sites that had trees in the riparian zone were primarily deciduous.

Impaired riparian function is evident in other components of the Reach Scale Analysis (Cramer 1997) and work by the Squaxin Island Tribe (Schuett-Hames and Child 1996) which document low canopy closure, water temperatures exceeding the State Water Quality Standards threshold, lack of large wood, and other factors associated with riparian buffers.

Table 16: Riparian buffer widths along the Descutes River(Source, Cramer 1997) [Note: Riparian buffer width was not identified on approximately half of the records in the database. A high proportion of records in the 10-30 m buffer range are estimated at 10 m. Data in table reflects only buffer width and not type or age/size of vegetation.]

Riparian Buffer Width (m)	Left Bank (miles)	Right Bank (miles)	Both Banks (miles)
<10	14.37	13.40	8.92
10-30	13.84	13.30	8.01
>30	0.90	1.86	0.51

The Squaxin Island Tribe (1991) also noted lack of canopy cover in sections of Huckleberry, Buck, and Ware creeks, all tributaries to the upper Deschutes River. Schuett-Hames and Child (1996) documented canopy closure below that necessary to maintain stream temperature in stream segments in both McLane and Swift creeks. Other creeks with identified riparian concerns include Green Cove Creek (Alexander 1998), Woodard Creek (Butkus and Lynch 1996, Thurston County et al. 1995), and Woodland Creek (Butkus and Lynch 1996, Thurston County et al. 1995).

Action Recommendation – The following salmonid habitat restoration actions are recommended:

- restore functional riparian areas (site potential tree height) along streams and rivers,
- preclude direct animal access into riparian areas that are being restored,
- restore natural densities of mature conifers in riparian zones that have converted to primarily deciduous trees,
- protect integrity of channel migration zone by establishing and maintaining riparian buffers starting from the edge of the channel migration zone.

Water Quality

There are a number of water quality concerns in the freshwater and marine areas of WRIA 13. Table 17 presents a list of waters that are currently identified on the 303(d) list as waters not in compliance with state standards.

There are specific point discharge sources, such as the LOTT sewer outfall and the Cascade Pole site (currently undergoing cleanup under the Model Toxics Control Act (MTCA)). Many of the water quality concerns, however, are the result of non-point sources. Some of these water quality concerns (temperature, dissolved oxygen, fine sediment, large woody debris, instream flow) have very clear direct linkages to salmonid survival. Other water quality factors, such as fecal coliform (probably the most frequently monitored water quality component), have less clear linkages to salmonid survival and productivity. Fecal coliform, however, is an indicator of activities in the watershed that can adversely affect salmonids. These activities include direct animal access to streams which can affect bank stability, high levels of fine sediments in the gravel substrate, high nutrient levels to the streams which may cause excessive aquatic plant growth, and upsets the balance of nutrients and productivity in the marine environment. The water quality in both Capitol Lake and Black Lake have been identified as of concern; it is unknown what effect these have to fish passage and survival in Percival Creek and to adult salmon returning to the Deschutes River.

Table 17: WRIA 13 waterbodies that are on the federal Clean Water Act Section 303(d) list (Source – Barecca, 1998)(omits 1998 recommended changes, which have yet to be adopted)

Water Body	Water Quality Concerns
Nisqually Reach	Fecal coliform
Henderson Inlet	Fecal coliform and dissolved oxygen
Budd Inlet (outer)	Dissolved oxygen
Budd Inlet (inner)	PCBs, heavy metals, Napthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, 2-Methylnapthalene, Fluoranthene, Pyrene, Benz(a) Benzo(b,k) fluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene, Benzo(g,h,iI) perylene, Butyl Benzyl Phthalate, Bis(2-ethyl hexyl) Phthalate, Sediment Bioassay, Benz(a)anthracene, Benzo(b)fluorene, Benzo(k)fluorene, Chrysene, Dissolved Oxygen, pH, fecal coliform
Deschutes River	Temperature, pH, fecal coliform, instream flow, fine sediment, large woody debris
Ayer (Elwanger) Cr.	Fecal coliform, pH, dissolved oxygen
Reichel Creek	Fecal coliform
Huckleberry Creek	Temperature
McLane Creek	pH
Indian Creek	Fecal coliform
Moxlie Creek	Fecal coliform
Mission Creek	Fecal coliform
Dobbs Creek	Fecal coliform, pH
Woodland Creek	Temperature, fecal coliform, dissolved oxygen, instream flow
Woodard Creek	Dissolved oxygen, pH, fecal coliform
Sleepy (Libbey) Cr.	Fecal coliform, pH, dissolved oxygen
Capitol Lake	Total phosphorous
Ward Lake	PCB-1260

Perhaps the largest threat to many streams in this WRIA, which is being rapidly developed, is the impact of stormwater runoff. Increased effective impervious surfaces in a watershed seriously alter the natural hydrologic regime by increasing the frequency and magnitude of peak stormwater flows and decreasing summer base flows. Stormwater runoff from roads, parking lots, and other impervious surfaces often carry gas, oil, pesticides, and other toxics that may not show up in regularly scheduled water quality sampling, but may be acutely toxic after early fall freshets (early fall rain events that are sufficient to result in overland runoff and outflow from stormwater detention facilities). They may also accumulate in the stream or marine sediments, affecting the production of benthic organisms that provide prey for salmonids. This is of particular concern during the first significant fall rain events after summer dry spells, which results in high concentrations of accumulated contaminants.

Another key concern with stormwater runoff is the high level of fine sediment often found in the runoff. High levels of fine sediment in gravels is identified as a habitat factor of concern in several of the streams in WRIA 13.

Action Recommendation – The following salmonid habitat restoration actions are recommended:

- continue to actively develop and implement strategies to prevent point and non-point source water quality impacts to salmonid habitat,
- reevaluate stormwater recommendations in basin plans in light of best available science, and implement to mitigate for adverse changes to stream hydrology,
- increase enforcement of existing water quality regulations.

Water Quantity

The basic water quantity habitat issue of concern is alteration of the natural hydrologic regime. Included are alteration of the frequency and magnitude of high flow events (usually associated with increased stormwater runoff from impervious surfaces), and reduction of summer base flows that affect the salmonid rearing capacity of streams (usually associated with reduced infiltration of groundwater, water withdrawals, or excess coarse sediment that can cause the flow to go subsurface).

The streams in WRIA 13 that are currently listed on the 303(d) list for instream flows are Woodland Creek and the Deschutes River. The Deschutes watershed also has an established rule (Chapter 173-513 WAC, 1980) that applies to waters within the Deschutes River basin for the purpose of retaining perennial rivers, streams and lakes in the basin with instream flows and levels necessary to provide protection for wildlife, fish, scenic, aesthetic, environmental values, recreation, navigation, and water quality. Instream flows and closures for the Deschutes River from the confluence of the river with Capitol Lake upstream to Deschutes Falls (RM 41) are presented in Table 18.

Table 18: Established minimum instream flows and water allocation closures in WRIA 13 (Source – Chapter 193 WAC)

Stream or River	Instream Flow Req./Closure
Deschutes River below Deschutes Falls	
December 15 – March 31	400 cfs.
April 1 - April 14	350 cfs.
April 15 – October 31	Closed
November 1 – November 14	150 cfs.
November 15 – November 30	200 cfs.
December 15 – December 14	300 cfs.
Percival Creek	Closed
Woodland Creek	Closed
Adams Creek	Closed
Woodard Creek	Closed
Green Cove Creek	Closed
McLane Creek	Closed

Flows typically are lowest in late summer and impact juvenile salmon (coho) and steelhead rearing in the watershed, adult salmon (most likely chinook) migrating and spawning in the river, and resident trout present in the river. Low flows limit the amount of wetted area available to rearing salmonids, and also limit productivity due to increased water temperatures and decreased dissolved oxygen. Flows were consistently below the summer minimum instream flow between 1990 and 1995 and are not adequate for salmon. Further study is warranted to determine the extent of impact of low instream flow to juvenile and adult salmonids. Water quantity concerns should be actively considered by the WRIA 13 HB 2514 Watershed Planning Unit to ensure that current instream flow requirements afford protection to salmonids, and to ensure that appropriate instream flows are achieved.

Summer low flows in Woodland Creek are a habitat limiting factor. The reach of Woodland Creek from Lake Lois to below Martin Way typically goes dry during the summer months and summer flows elsewhere in the system are low. Other streams in WRIA 13 where low flows were identified as a habitat limiting factor include Chambers Creek ditch (13.0034)(Thurston County 1995), and McLane Creek (Williams et al. 1975).

For Woodland and Woodard creeks, the largest threat to salmonids is the change in the natural flow regime resulting from the rapid urbanization of the watershed. Increased impervious surface from urban development typically results in increased peak flow storm runoff in the winter and reduced base flows in the summer. Other stream basins in WRIA 13 are also under intense development pressure. Unless the natural flow regime can be maintained in developing basins, salmonid habitat will also be adversely impacted.

Action Recommendation – The following salmonid habitat restoration actions are recommended:

- continue to actively develop and implement strategies to prevent stormwater peak flow impacts to streams in developing/developed areas,
- refer salmonid instream flow concerns to the WRIA 13 HB 2514 Watershed Planning Unit, particularly in those systems where water appropriations are already limited due to low flow concerns (closure of Long, Hicks, and Patterson lakes should be actively considered in response to low flow concerns in Woodland Creek).

Biological Processes

The presence of Reed canarygrass in stream channels and in adjacent riparian zones was identified for many of the drainages in WRIA 13. Reed canarygrass presence is typically associated with areas where natural woody riparian vegetation has been removed or density reduced. It typically does not provide any significant riparian function, and will tend to encroach on the channel, removing portions of the channel from accessible and useable area for salmonids. Reed canarygrass can also impair surface flows and, in some cases, eliminate identifiable surface channels. No specific locations were identified where Reed canarygrass is a limiting factor, although the concern is pervasive throughout streams in the lower elevation portions of WRIA 13.

Action Recommendation – The following salmonid habitat restoration actions are recommended:

- further investigate salmonid friendly control methods for Reed canarygrass, and
- reestablish functional mature riparian vegetation to provide shade that will inhibit growth of Reed canarygrass.

Lakes

See Water Quality Section for Deschutes River, where Capitol Lake concerns are identified.

Estuarine

Juveniles of the different salmon species use estuarine habitats to varying extents. Of all the salmon species and "life stage types," ocean-type chinook are most dependent on estuaries for rearing. Use of estuaries by juvenile chinook and chum for rearing ranged from one third (Skagit R., Congleton et al. 1982, as cited in Aitkin 1998) to one-half (Skagit R., Hayman et al. 1996, as cited in Aitkin 1998) of all downstream migrants. Depriving migrating juvenile chinook access to estuarine habitat appears to decrease their overall survival (Macdonald et al. 1988, as cited in Aitkin 1998). An assessment of primary critical habitat issues affecting chinook salmon in fifteen Washington watersheds concluded that estuarine loss was a limiting factor in fourteen of the watersheds (Bishop and Morgan 1996, as cited in Aitkin 1998).

The highest growth rates for some species of salmon (specifically chinook and chum) have been recorded in estuaries (Simonstad et al. 1982, as cited in Aitkin 1998). Chinook rearing in estuaries had a higher growth rate than river-rearing conspecifics in the Sacramento (Kjelson et al. 1982, as cited in Aitkin 1998) and Skagit (Congleton et al. 1982, as cited in Aitkin 1998) rivers.

Chinook, which exhibit the greatest dependence on estuaries, have a more diverse estuarine diet than coho and chum, which are less dependent on estuaries and have a more specialized estuarine diet (Healy 1982, Pearce et al. 1982, Simonstad et al. 1982, as cited in Aitkin 1998). There also appears to be an affinity, by all salmon species, for benthic food items while residing in the upper estuary as fry, which then changes to pelagic food items as salmon grow and move to deeper water with higher salinity (Healy 1982, Macdonald 1987, Wissmer and Simonstad 1988, as cited in Aitkin 1998).

Many of the benthic food items that salmon feed on are dependent on detritus for food. Juvenile chinook and chum salmon residing in estuaries are dependent on benthic organisms (harpactacoid copepods) which are, themselves, dependent on detritus (Sibert et al. 1977, Sibert 1979, as cited in Aitkin 1998). Healey (1982, as cited in Aitkin 1998) reported that juvenile salmonids tend to congregate in areas where estuary morphology favored detritus retention.

Loss of Estuarine Habitat

Salmonids have naturally adapted to conditions that provide a brackish or lower salinity transition zone between fresh and salt water. This allows salmonids to gradually adapt on their juvenile migration to saltwater and on their adult migration back to fresh water. The estuary in the southern portion of Budd Inlet has been significantly altered by diking and associated freshwater retention in Capitol Lake. The natural estuary historically extended upstream to the base of Tumwater falls. This would also have created a natural estuary at the mouth of Percival Creek. However, prior to the introduction of salmon into the Deschutes system, Capitol Lake was formed by diking off the estuary at 5th Avenue in Olympia and installing a tide gate to allow the area upstream to be maintained as freshwater. This action removed all of the area occupied by Capitol Lake from the natural estuary, and established a much more abrupt change from fresh to saltwater. The low salinity zone in Budd Inlet was moved downstream to just below the tide gate. Juvenile and adult salmonids in the Deschutes/Percival system must now negotiate a more direct transfer from fresh to salt water, and vice versa, than would have occurred under natural estuarine conditions. However, it must be remembered that the creation of Capitol Lake actually occurred prior to the introduction of salmonids to the Deschutes River, and the only salmonids that experienced a decrease in estuarine area from historic conditions are those originating from Percival Creek and other tributaries to Budd Inlet.

Alteration and Loss of Near-shore Habitat in WRIA 13

The estuarine area of WRIA 13 is at the southern terminus of Puget Sound. The area consists of the Nisqually Reach, Dana Passage, Henderson Inlet, Budd Inlet, and Eld Inlet (Figure 9). The marine areas of WRIA 13 represent a wide spectrum of land use and development intensity, from heavy industrial development in the southern portion of Budd Inlet to the rural residential development found throughout the remainder of the shorelines. The Nisqually Reach and Dana Passage have relatively high water exchange and flushing in comparison to the inlets. The major impacts to salmonids are likely associated with bulkheaded shorelines and associated loss of benthic invertebrate and baitfish production. The estuarine inlets have a broad variety of problems associated with water and sediment quality, as well as impacts from shoreline bulkheading.

Dredging and Filling - Dredging periodically occurs in the southern end of Budd Inlet to maintain vessel traffic channels from East Bay into Budd Inlet, and for log and container shipping access to Port of Olympia facilities. No information was located regarding potential dredging effects to salmonids in Budd Inlet.

Bulkheads - Thurston County marine shorelines represent the only marine shoreline area in Washington where a comprehensive inventory of marine bulkheads has been done. The summary was based on a review of aerial photographs from 1977 and 1992, plus a field verification in 1993 (Morrison et al. 1993). The use of aerial photographs alone led to an error rate (both false indications of armoring when no armoring was present, and false indications of no armoring when armoring was indeed present) of approximately 34% (Kettman 1995). The conclusions of the study are presented in Table 19. Approximately 30% of the Thurston County marine shoreline has been armored, with the amount of armored shoreline roughly doubling from 1977 to 1992. The rate of new armoring outpaced the rate of residential construction along marine shorelines by 42% during the period studied, with much of the increase occurring on previously developed residential shoreline (J. Kettman, personal communication). In recent years, approximately 67% of permits issued for armoring have been for replacement projects. Still, on average, each year an additional 0.5 mile of shoreline was armored in Thurston County. As of the 1993 study, less than 50% of marine shorelines in Thurston County had no upland development or armoring present (Kettman 1995).

Nearshore areas provide support for salmonids in a number of ways:

1. migration corridors for juvenile salmon and protection from predators,
2. suitable substrate and detritus retention to produce the benthic food organisms on which many juvenile salmonids are dependent, and
3. primary production areas for baitfish species (primarily surf smelt and sand lance) which support salmonids at later life stages.

These areas are particularly important for chinook and chum, which have the greatest dependence of the salmon species on estuarine and near-shore habitats (Aitkin 1998).

The identified effects of shoreline armoring on finfish resources have not been specifically assessed, nevertheless, all indications are that shoreline armoring adversely effects ecosystem function and the fish resources that utilize these habitats. Schreffler et al. (1995) identified several case studies of the physical effects for shoreline armoring, and identified the potential and observed effects of shoreline armoring. The following impacts have been identified as typically being associated with armoring of shorelines with bulkheads (Canning and Shipman 1995, Schreffler et al. 1995):

1. sediment supply to beaches is cut off, leading to starvation of the beaches of the sand and other fine-grained materials that typically make up a beach,
2. the hard face of the shoreline armoring, particularly concrete bulkheads, reflects energy back onto the beach, thus exacerbating beach erosion,

3. over time, sand and gravel beaches are transformed to large gravel and cobbles, possibly to bedrock or hard clay, exposing the footings of bulkheads and leading to undermining and failure,
4. embedded logs and vegetation which shades the upper beach are eliminated, thus degrading the value of the beach for baitfish spawning habitat,
5. transformation of the character of the beach affects the kinds of life the beach can support, and
6. the degradation of the beach results in loss of the shallow, nearshore migration corridors for salmonids that provide protection from predation.

Some of the observations in Schreffler et al. (1995) are the result of an interview with D. Pentilla (WDFW), who has extensive experience evaluating shorelines for baitfish spawning potential. He reported the following observed effects of shoreline armoring:

1. reduced sediment input from feeder bluffs to nearshore area,
2. permanent loss of habitat above +5 feet Mean Low-Low Water (MLLW) (Note: This represents the suitable habitat area for surf smelt and sand lance spawning),
3. loss of riparian vegetation that provides shade to the upper beach (Note: shade minimizes desiccation of baitfish eggs that are laid in high intertidal gravels and sands), and
4. changes in substrate from finer to coarser-grained material.

Table 19: Summary of marine shoreline armoring in WRIA 13 (from Kettman 1995) (Note: Eld Inlet includes inlet shorelines in both WRIA 13 and WRIA 14)

	Budd Inlet	Dana Passage	Eld Inlet	Henderson Inlet	Nisqually Reach	Total
Shoreline Length (feet)	73,051	25,879	181,779	101,511	92,531	474,751
Feet of Shoreline Armored in 1977	20,735	2,767	29,977	9,996	5,970	69,445
Feet of Shoreline Armored in 1993	34,108	8,485	63,701	19,177	19,594	145,065
Increase from 1977 to 1993 (feet)	13,373	5,718	33,724	9,181	13,624	75,620
Percent Change	164 %	307 %	212 %	192 %	328 %	209 %
Percent of Armored Shoreline Length by Water body (1993)	47 %	33 %	35 %	19 %	21 %	31 %

Baitfish, upon which chinook and coho salmon are known to prey, are particularly susceptible to impacts of shoreline armoring. Because surf smelt (<u>Hypometus pretiosus pretiosus</u>) spawn high in the intertidal zone (from +7 ft mean low-low water (MLLW) to extreme high-high water (EHHW) in fine grained substrate, they are particularly susceptible to permanent habitat loss. Sand lance (<u>Ammodytes hexapterus</u>) form localized schools that are usually associated with clean sandy bottoms. They are susceptible to deleterious effects of shoreline armoring because of preference for spawning high in intertidal (+5 feet MLLW to mean high-high water (MHHW)), in substrates varying from sand to sandy gravel (Canning and Shipman 1995).

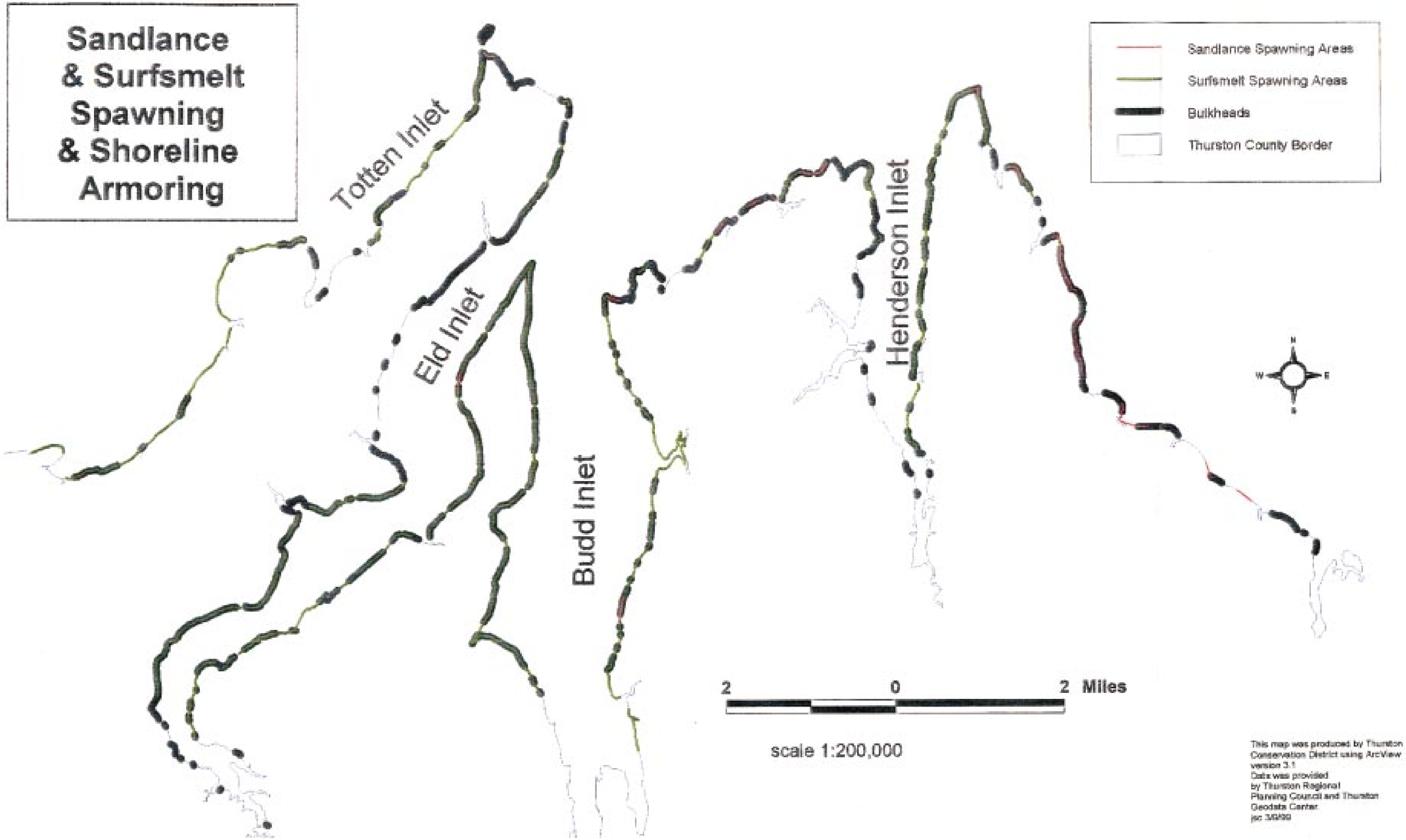

Figure 9: Occurence of shoreline bulkheads on documented baitfish (surf smelt and sandlance) habitat

Potential loss of baitfish production is particularly at risk in areas such as Eld Inlet, which has high shoreline development density (many areas have one home per 100 feet of shoreline), and where the outer 2/3 of the shorelines in the bay are identified as surf smelt spawning habitat. Table 20 and Figure 9 indicate the extent to which surf smelt and sandlance habitat may be affected by the extent of bulkheading of WRIA 13 marine shorelines through 1993. Note that there are unarmored segments within the shorelines shown as armored in Figure 9 that are not apparent due to the level of map resolution. The estimates of total impacts are likely underestimates, however, because many unarmored parcels are immediately adjacent to armored parcels on either side and are likely to experience similar impacts to those on the armored sites.

As noted above, shoreline armoring is known to affect littoral drift. The increased energy from wave reflection off the vertical face of bulkheads is likely to result in degradation of the beach materials, and loss of ability of the beach to retain detritus. One of the major biological effects that results from disrupting littoral drift is the loss or reduction of nutrients and food sources needed to sustain juvenile salmonids. Because juvenile salmonids are actively feeding during their outmigration, they need prey of appropriate quantities at the right time. Thus, growth rates of juvenile salmonids may be negatively impacted if their natural food supply is reduced or cut off due to shoreline armoring, adversely affecting their survival (Canning and Shipman 1995).

While individual, small armoring projects may have little measurable ecological effect, incremental increases in the number of small projects within an embayment would be expected to result in significant effects to the bay ecosystem. Thurston County contains mostly depositional beaches (Downing 1983 as cited in Schreffler et al. 1995, Canning and Shipman 1995) and modification in beach elevations as well as coarsening of substrate would be predicted because of armoring. Based on comparisons of surveys made in 1911-12 and 1977, southern Puget Sound showed the second largest increase in kelp distribution (+332%) among all regions of Puget Sound (Thom and Hallum 1990, as cited in Schreffler et al. 1995). Kelp presence is typically associated with the presence of solid or coarse substrate. Linkage between armoring, sediment composition, and kelp distribution requires further study, but may prove to be an indicator of cumulative effects of shoreline armoring in the region (Schreffler et al. 1995).

Table 20: Extent to which baitfish (sandlance and surf smelt) habitat has been bulkheaded in WRIA 13 (through 1993)

Sandlance	Length of documented sandlance shoreline spawning habitat	23, 894 feet
	Length of armored shoreline coinciding with sandlance spawning habitat	13,885 feet
	Percent of sandlance spawning habitat that is armored	58%
Surf Smelt	Length of documented surf smelt shoreline spawning habitat	161,436 feet
	Length of armored shoreline coinciding with surf smelt spawning habitat	83,306 feet
	Percent of surf smelt spawning habitat that is armored	51%

Bulkheading effects vary between construction methods. Ensuring that bulkheads are constructed above the ordinary high water mark, wherever practicable can minimize adverse effects of bulkheading to shoreline habitats. Rock bulkheads are also considered to afford greater protection to shoreline resources than concrete bulkheads (WDFW Hydraulic Code Rules, WAC 220-110), and have been reported in some cases to actually increase small gravel abundance on the shoreline (Joe Robel, personal communication 1999).

Action Recommendation – The following salmonid habitat restoration actions are recommended:

- minimize further marine bulkheading in WRIA 13 that will adversely affect nearshore production of benthic invertebrates and baitfish resources (this will likely require alteration of the current exemption under the Shoreline Management Act), and
- local governments should review existing ordinances and resource protection mechanisms to ensure they provide protection of the marine nearshore environment.

Alteration of Freshwater Inflows

Freshwater inflows from the Deschutes River and Percival Creek to Budd Inlet are altered by the retention in Capitol Lake prior to release through the tide gate into Budd Inlet. The amount of water entering Percival Creek and Capitol Lake has also been altered by routing a significant portion of the Black Lake discharge through Black Lake Ditch to Percival Creek. Black Lake historically discharged primarily through the Black River to the Chehalis River system. Capitol Lake has little storage capacity, and for most of the year it is a flow through system. During winter months, the slight water detention time provided by the lake allows large amounts of fine sediment to settle in the lake rather than passing through to Budd Inlet. Capitol Lake is also drawn down periodically during summer months to flush rearing hatchery chinook, facilitate lake maintenance, and to kill aquatic vegetation and undesirable freshwater fish species in the lake. The primary effects of Capitol Lake are interruption of sediment delivery to Budd Inlet, and potential increases in temperature of fresh water and reduced dissolved oxygen released to Budd Inlet. The southern portion of Budd Inlet is on the 303(d) list for water temperature and low dissolved oxygen, as well as a long list of other contaminants.

Estuarine water quality

Henderson Inlet has significant fecal coliform contamination from a combination of urban, residential, and agricultural sources. Urban stormwater was previously thought to be the primary source (Harrison and Hofstad 1988, Thurston County 1989), but it is unclear whether this remains true (Darin Cramer, personal communication). Woodard Bay Natural Resource Conservation Area (NRCA) in Henderson Inlet represents the largest seal haulout area in south Puget Sound. The harbor seal population increased from 40 in 1977 to 228 in 1984, primarily as a result of passage of the Marine Mammal Protection Act in 1972. The Woodard Bay NRCA Preliminary Reconnaissance Report (Thurston Regional Planning Council 1988) indicates that although there is fecal coliform contamination from seals at this site, it does not contribute significant fecal coliform to Henderson Inlet. The report also indicates that salmon are a minor part of the seal's diet. In addition, there are a large number of creosote-treated pilings remaining at the Woodard Bay NRCA site. Creosote is known to be toxic to marine life, and removal of the pilings should be considered.

Budd Inlet is characterized by poor tidal flushing. The lower portion of the inlet is dominated by urban, port, marina, and industrial related facilities. The urban shoreline represents approximately one third of the inlet. The Department of Health prohibits any commercial shellfish harvest south of Gull Harbor in the inlet, due to water quality concerns (Budd Inlet/Deschutes R. Watershed Action Plan 1994). Recreational boating contributes fuel, sewage and refuse spillage to the waters. Sediment sampling indicates stormwater inflows are contaminated with heavy metals and organics, bacteria, and nutrients. The McFarland/Cascade Pole site in the industrial Port area of Budd Inlet has shown significant contamination from wood preservatives and is currently undergoing Superfund cleanup. Both the McFarland/Cascade Pole and West Bay storm drain sites indicated chemical presence >100 times that at the reference site. The City of Olympia has two combined sewer overflows (CSO) and more than 50 storm drains that discharge to Budd Inlet (Jacobsen and Canterbury, 1991). Primary bacterial contamination sites, reflecting bacterial presence >10 times that at the reference site, include Moxlie Cr., Boston Harbor, Ellis Cr., and south of Tykle Cove. Secondary bacterial contamination sites, reflecting bacterial presence at 1-10 times that at the reference site, include Tamoshan, Beverly Beach, Athens Beach WWTP, Butler Cove, and north of Priest Point. The highest nutrient concentrations measured in the Budd Inlet-Deschutes R. Watershed Characterization: Part II Water Quality Study (1993) were at the sites affected by the LOTT wastewater treatment plant outfall. Numerous pipes discharging stormwater and subsurface water contribute to bacterial and nutrient loading. Sediment sampling indicates stormwater inflows are contaminated with heavy metals and organics, bacteria, and nutrients. Eutrophication of upper Budd Inlet is well documented (URS 1986 as cited in Budd Inlet/Deschutes R. Watershed Action Plan 1994). The boundary of the area impacted by high nutrient levels and low dissolved oxygen (levels at several sites <3.0 mg/L during late summer) has not been delineated. Outer Budd Inlet is on the 303(d) list of impaired water bodies with dissolved oxygen and pH not meeting state standards. In addition to the chemical compounds and heavy metals noted above, inner Budd Inlet is on the 303(d) list of impaired water bodies with fecal coliform, dissolved oxygen, and pH not meeting state standards (Barecca 1998).

Other Budd Inlet concerns that warrant further investigation include: 1) studies to determine the effects of log rafting (significant benthic effects from log rafting documented in Port Angeles harbor (SAIC, 1999), and 2) investigation of the mothballed fleet site near Gull Harbor in Budd Inlet, where high concentrations of copper, lead, and zinc have been identified in sediments (in Budd Inlet/Deschutes R. Watershed Action Plan 1995).

Although the data is somewhat dated, Harrison and Hofstad (1988) reported that all marine waters in Eld Inlet met Class A water quality standards. The sources of fecal coliform are more difficult to define than in Henderson Inlet. Stormwater releases are generally okay except for the most significant storms. Failing septics along the shoreline are thought to contribute. Perry and McLane creeks are thought to be the primary sources of fecal coliform contamination, with the primary source of fecal coliform in McLane Creek considered to be animal wastes. Septic and stormwater are lesser contributors of fecal coliform to southern portion of inlet. The southern portion of the inlet has been closed to shellfish harvest since the early 1980s due to shellfish contamination, but the rest of the inlet was upgraded from “conditionally approved” to “approved” in 1998 (Determan 1999).

Little information on the specific effects of nutrients to finfish was presented in the literature. However, significant sampling for fecal coliform has been conducted in the inlets and tributary streams. Elevated fecal coliform levels are typically associated with septics or animal keeping , and are likely an indicator of elevated nutrient levels. The potential impacts of elevated nutrients are unknown at this time.

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- continue to develop and implement point and non-point water quality control measures,
- clean up known contamination sites, and
- evaluate feasibility of removal of creosote-treated piling at Woodard Bay NRCA site.

WRIA 13 HABITAT LIMITING FACTORS DISCUSSION – BY DRAINAGE

The TAG has identified habitat limiting factors for the following streams, in which salmon or steelhead presence has been identified. Specific habitat assessment data is referenced where available. Many streams or stream segments have no habitat assessment data available. For these streams or segments, qualitative descriptive information is included where TAG members have contributed specific comments.

Unnamed (Mill Bight) Creek 13.0001

No information on habitat limiting factors was identified by the TAG for this stream. The culvert inventory includes a reference to a barrier culvert at 78th Ave NE (just east of Baird Rd.), but repair is estimated to result in no gain of salmonid habitat.

Dobbs Creek 13.0005

No information on habitat limiting factors was identified by the TAG for this stream. Dobbs Creek is on the 303(d) list for fecal coliform and pH. Although there is no direct link between fecal coliform and salmonid health, elevated fecal coliform counts are often indicative of other concerns that affect salmonids, including high nutrient levels, direct animal access to streams, poor riparian condition, etc. Instream flows should be evaluated to determine effects to salmonid production.

Action Recommendation – The following salmonid habitat restoration actions are recommended:

- identify and correct sources of fecal coliform contamination,
- refer the need for instream flow evaluation to the WRIA 13 HB 2514 Watershed Planning Unit.

Woodland Creek 13.0006

The key habitat factors limiting salmonid production in Woodland Creek and tributaries, in order of importance, are:

1. alteration of the natural flow regime,
2. barriers to fish passage, and
3. water temperature/excess fine sediment/lack of large woody debris (LWD).

The largest threat to salmonids is the change in the natural flow regime resulting from the rapid urbanization of the watershed. Increased impervious surface from urban development is increasing peak flows in the winter and reducing base flows in the summer. Woodland Creek is on the 303(d) list for instream flow concerns. The key flow concerns are from intensified peak flows from suburban development (particularly near Martin Way Village) and low base flows, particularly between Martin Way and Lake Lois. Woodland Creek now regularly goes dry in the late summer between Martin Way and Lake Lois; this reach used to support juvenile rearing over the summer and spawning in the fall. Stormwater facilities that specifically contribute to instream flow and water quality problems in Woodland Creek are located near Top Foods and the stormwater outfall near Carpenter Road.

The Woodland and Woodard Comprehensive Drainage Basin Plan (Thurston County et al. 1995) outlines a number of stormwater facilities that, if constructed, will lessen the impact of development on instream flow and water quality. The status of these projects and their design and cost/benefit ratio should be reevaluated based on the latest scientific information regarding salmonid restoration. A new priority list of stormwater projects should be developed and funded that provides the most benefit to salmonid species. Larger issues of instream flow and hydraulic continuity should be actively considered and addressed by the WRIA 13 HB 2514 Watershed Planning Unit.

At least seven culverts on mainstem Woodland Creek have been assessed in the WDFW Fish Passage Barrier Database (WDFW SSHEAR 1999, Table 8). None of these are identified in the database as being current fish passage barriers, although the Thurston Conservation District has recently received a contact indicating that conditions at the culvert under Pleasant Glade Road may have changed, creating at least a partial barrier to fish passage. Three culverts have been assessed on Jorgenson Creek (13.0008), all of which are identified as barriers (Table 9). One culvert on Fox Creek (13.0009) has been assessed as not currently a barrier (Table 8); the TAG, however, indicated there may be a barrier culvert on Fox Creek. Three culverts on Eagle Creek (13.0010) and one culvert on an unnamed tributary (13.0010A) have been assessed and are all indicated as fish passage barriers (Table 9). John Konovsky also reports a fish passage barrier on private property that may not be included in the Fish Passage Barrier Database.

Woodland Creek is on the 303(d) list for high fecal coliform, and for low dissolved oxygen (DO) and high temperature (RM 4.2, Butkus and Lynch 1996). It was also on the list for turbidity, but removal of this factor was proposed in 1998 because of scientific error. Patterson and Dickes (1994, as referenced in Barecca 1998) found that City of Lacey stormwater run-off caused high bacteria and turbidity, and contamination of sediments with metals and organic compounds; benthic macroinvertebrates were pollution tolerant species; low flows caused violations of water quality standards for temperature, DO, pH, and characteristic uses (fish migration, spawning, and rearing); and sediment problems were found at the Martin Village construction site. The riparian corridor on Woodland Creek has been impaired by the removal of riparian vegetation, by direct animal access to the stream at several locations, and by the lack of conifer in remaining riparian buffers. Lack of LWD has been identified as a habitat concern (Thurston County et al. 1995). LWD is necessary to create pools and habitat diversity and complexity in this channel, which is currently characterized as monotypic runs. Reestablishment of riparian buffers where they have been removed, and reestablishment of conifers in riparian buffers that are primarily deciduous, are important to provide protection from elevated temperatures and to reestablish overall riparian function.

High levels of fine sediment in the stream substrate impair survival of eggs deposited in the substrate. High levels of fine sediment have been reported in Woodland Creek substrate, particularly subsequent to construction of Martin Village (Patterson and Dickes 1994, as referenced in Barecca 1998). During and immediately after construction, there was high turbidity and fine sediment bedload reported. The high turbidity has declined, but high fine sediment levels in the substrate remain. There is little quantitative substrate information for fine sediment levels in Woodland Creek; additional sampling would help determine the magnitude of impact. Fine sediment in the substrate is also identified by the TAG as a factor limiting salmonid production in Jorgensen Creek (13.0008). Additional sampling would help determine the magnitude of impact. Unrestricted livestock access is identified as a factor limiting bank stability and substrate condition in Eagle Creek (13.0010) (John Konovsky, personal communication).

Don Willson (City of Lacey) reports accelerated bank erosion on Woodland Creek between Lake Lois and Martin Way. The impact to salmonids is undetermined at this time, as the bank erosion is occurring in a reach of the stream that is dry most years during summer low flow. Eroded sediments may be affecting the substrate downstream of the erosion site.

Action Recommendations - The following salmonid habitat restoration actions are recommended:

- reevaluate the Woodland and Woodard Comprehensive Drainage Basin Plan (Thurston County et al. 1995), which outlines a number of stormwater facilities that, if constructed, will lessen the impact of development on instream flow and water quality; reevaluate the status of these projects, their design, and cost/benefit ratio based on the latest scientific information regarding salmonid restoration; develop and fund a new priority list of stormwater projects that provides the most benefit to salmonid species,
- refer instream flow concerns to the WRIA 13 HB 2514 process,
- prioritize and correct fish passage barriers,
- restore LWD presence in the channel, both in short-term and long-term,
- restore functional riparian zones throughout watershed, including reestablishment of high density conifer presence in the riparian zone,
- evaluate fine sediment impacts and develop plan to restore substrate function, if needed, and
- identify sites with unrestricted livestock access to the channel, report to Thurston County Health Department for correction.

Woodard Creek 13.0012

The key habitat factors limiting salmonid production in Woodard (Woodward) Creek and tributaries, in order of importance, are:

1. alteration of the natural flow regime,
2. barriers to fish passage, and
3. water temperature/lack of large woody debris (LWD).

The largest threat to salmonids is the change in the natural flow regime resulting from the rapid urbanization of the watershed. Increased impervious surface from urban development is increasing peak flows in the winter and reducing base flows in the summer. Stormwater facilities that specifically contribute to instream flow and water quality problems in Woodard Creek are located near Fones/Ensign Roads. The Woodland and Woodard Comprehensive Drainage Basin Plan (Thurston County et al. 1995) outlines a number of stormwater facilities that, if constructed, will lessen the impact of development on instream flow and water quality. The status of these projects and their design and cost/benefit ratio should be reevaluated based on the latest scientific information regarding salmonid restoration. A new priority list of stormwater projects should be developed and funded that provides the most benefit to salmonid species. Larger issues of instream flow and hydraulic continuity should be actively considered and addressed in the WRIA 13 HB 2514 Watershed Planning Unit.

Five culverts on Woodard Creek and three culverts on unnamed tributaries to Woodard are included in the Fish Passage Barrier Database (SSHEAR 1999, Table 8). None of the mainstem Woodard Creek culverts are identified as current fish passage barriers. The three culverts on unnamed tributaries at Libby Rd. NE, Lemon Rd. NE, and 26th Ave. NE are all identified as current barriers. The Lemon Rd. culvert is scheduled for replacement this summer.

Woodard Creek is on the 303(d) list for high fecal coliform , pH, and low dissolved oxygen (DO) (Butkus and Lynch 1996; Barreca 1998). The riparian corridor on Woodard Creek has been impaired by the removal of riparian vegetation, by direct animal access to the stream at several locations, and by the lack of conifer in remaining riparian buffers (Butkus and Lynch 1996, Thurston County et al. 1995). Darin Cramer (personal communication) indicates that the portion of the stream corridor upstream of 36th Avenue has severely compromised riparian areas in urban and residential areas. He also indicates significant impacts from the Interstate 5 interchange and alteration of the headwater wetlands. Lack of LWD has been identified as a habitat concern in several studies. LWD is necessary to create pools and habitat diversity and complexity in this channel, which is currently characterized as monotypic runs. Reestablishment of riparian buffers where they have been removed, and reestablishment of conifers in riparian buffers that are primarily deciduous are important to reestablish overall riparian function.

Action Recommendation: The following salmonid habitat restoration actions are recommended:

- reevaluate the Woodland and Woodard Comprehensive Drainage Basin Plan (Thurston County et al. 1995), which outlines a number of stormwater facilities that, if constructed, will lessen the impact of development on instream flow and water quality; reevaluate the status of these projects, their design, and cost/benefit ratio based on the latest scientific information regarding salmonid restoration; develop and fund a new priority list of stormwater projects that provides the most benefit to salmonid species,
- refer instream flow concerns to the HB 2514 process,
- prioritize and correct fish passage barriers,
- restore LWD presence in the channel,
- restore functional riparian zones throughout watershed, including reestablishment of high density conifer presence in the riparian zone, and
- preserve and restore headwater wetlands,
- identify sites with unrestricted livestock access to the channel, report to Thurston County Health Department for correction.

Sleepy Creek (Libbey Creek) 13.0015

No information on habitat limiting factors was identified by the TAG for this stream. Sleepy Creek is on the 303(d) list for fecal coliform, pH, and low dissolved oxygen.

Action Recommendation: The following salmonid habitat restoration actions are recommended:

- continue to actively work to address identified water quality problems.

Unnamed (Fish Trap) 13.0016

The Fish Passage Barrier Database (SSHEAR 1999, Table 9) indicates the presence of one culvert fish passage barrier on a tributary to this stream, under 81st Ave. NE. At this time no salmon or steelhead presence is known for this stream. A private landowner has raised stormwater impacts as an issue of concern.

Adams Creek 13.0018 and 13.0021

Three culverts have been assessed for fish passage in Unnamed 13.0018. Two of these culverts are identified as current fish passage barriers (47^{th} Ave. NE and Private Rd.). On Adams Creek, both the culverts under Boston Harbor Rd. and under a private drive at approx. RM 0.9 are identified as current fish passage barriers. Thurston County found fecal coliform bacteria levels that exceeded standards in Adams Creek. Thurston Conservation District has not had the cooperation of all livestock owners to correct livestock impacts to water quality.

Action Recommendation: The following salmonid habitat restoration actions are recommended:

- prioritize and correct identified fish passage barriers,
- identify and correct fecal coliform sources.

Ellis Creek 13.0022

The primary factor adversely affecting salmonid production in Ellis Creek is fish passage. Five culverts have been assessed in the Fish Passage Barrier Database (WDFW SSHEAR 1999). Three of these are identified as current barriers (Gull Harbor Rd. NE, Boston Harbor Rd. NE, and at 33^{rd} Ave.). In addition, there is one identified fish passage barrier culvert on each of the two tributaries (Unnamed 13.0023 and Unnamed 13.0024, neither of these have identified current salmon or steelhead presence). The culvert under Gull Harbor Rd. currently limits salmon access to the Ellis Creek watershed, but represents a very difficult restoration challenge due to the extent of road fill and cost of the project. Thurston County found fecal coliform bacteria levels that exceeded standards in Ellis Creek (Barecca 1998). A slug of sediment, from a recently completed development project on 26^{th} Ave., is currently moving through the system and causing substrate instability.

Action Recommendation – The following salmonid habitat restoration action is recommended:

- conduct a feasibility study to identify a cost effective solution to reestablish salmonid access to Ellis Creek.

Mission Creek 13.0025

This is a heavily developed urban creek in an older part of Olympia, with no significant stormwater controls. The creek experiences high peak flows due to direct stormwater outfalls to the creek, and the substrate has high fine sediment levels. The creek is reported to have little LWD, with little potential for LWD recruitment due to poor riparian condition. Riparian condition is relatively intact through the Priest Point Park reach (Darin Cramer, personal communication), but is generally impaired elsewhere, with high abundance of blackberry and non-native shrubs and deciduous trees (Andy Haub, personal communication). Although not in the WDFW fish barrier database, there are barriers at a road at Budd Inlet (partial barrier at gated culvert), at East Bay Drive (steep, small diameter culvert), and at Bethel Street (steep, small diameter culvert (Andy Haub, personal communication). Mission Creek is on the 303(d) list for fecal coliform. Although there is no direct link between fecal coliform and salmonid health, elevated fecal coliform counts are often indicative of other concerns that affect salmonids, including high nutrient levels, failing septics, direct animal access to streams, poor riparian condition, etc. Thurston County considers Mission and Indian/Moxlie creeks as having the poorest water quality of Budd Inlet tributaries (Barecca 1998).

Action Recommendation – The following salmonid habitat restoration action is recommended:

- develop and implement stormwater controls that will restore the natural hydrology of the basin,
- prioritize and correct identified fish passage barriers,
- restore functional riparian buffers upstream of Priest Point Park, and
- identify and correct fecal coliform sources.

Indian Creek 13.0026/Moxlie Creek 13.0027

There are a variety of habitat factors limiting salmonid production in these streams. The lower portion of both streams (approximately 0.5 mile) is encased in a culvert. The outfall of the culvert is located at the south end of East Bay, and the stream does not resurface upstream until in the vicinity of Interstate 5. The portion encased in the culvert flows under downtown Olympia. This represents a significant direct loss of habitat, both for spawning and rearing. The Fish Passage Barrier Database (SSHEAR 1999, Table 8) identifies 17 culverts that have been assessed on Indian Creek and four on Moxlie Creek. Eight of the culverts on Indian Creek are identified as current fish passage barriers (Table 9). Upstream salmon migration in Indian Creek extends only to the Interstate 5 culvert, which is considered a total barrier (Brian Benson, personal communication). There is limited habitat in the upper portion of Moxlie Creek, located within the City of Olympia Watershed Park. Habitat in the park is in fair condition, although there appears to be significant amounts of fine sediment in the substrate. The primary limiting factor, however, is thought to be limited passage and survival through the lengthy culvert in the lower watershed. Both Indian and Moxlie creeks are on the 303(d) list for fecal coliform. Although there is no direct link between fecal coliform and salmonid health, elevated fecal coliform counts are often indicative of other concerns that affect salmonids, including high nutrient levels, failing septics, direct animal access to streams, poor riparian condition, etc. Andy Haub (personal communication) indicates that water quality in Indian Creek is further impaired with high levels of turbidity, heavy metals, hydrocarbons, and nutrients. Thurston County considers Mission and Indian/Moxlie creeks as having the poorest water quality of Budd Inlet tributaries (Barecca 1998).

Action Recommendation – The following salmonid habitat restoration action is recommended:

- evaluate production potential of these streams in current and restored conditions, for use in cost/benefit evaluation of habitat restoration projects,
- develop and implement stormwater controls that will restore the natural hydrology of the basin,
- prioritize and correct identified fish passage barriers, and
- identify and correct water quality problem sources.

Deschutes River Mainstem 13.0028

The key habitat factors (not prioritized) limiting salmonid production in the mainstem Deschutes River (some which also affect salmonid utilization or production in the tributaries to the Deschutes R.) are:

- fish passage at the Capitol Lake tide gate,
- water quality effects (elevated temperature and phosphorous-induced algal blooms leading to reduced DO) in Capitol Lake,
- inadequate instream flow,
- lack of off-channel habitat,
- insufficient LWD,

- significantly impaired riparian condition and functions,
- elevated summer water temperature in the river, and
- altered estuary conditions.

These factors are discussed in the following descriptions of specific habitat factors.

Fish Passage

Adult salmonids are adversely affected by impaired function of the fish ladder at the Capitol Lake tide gate. Tidal water is not allowed to flow freely into the lake, and the lake level is maintained within a narrow range. A fish ladder was installed to provide passage for salmonids at most tidal stages. Chinook are also known to enter the lake through the tide gate opening. The entrance to the fish ladder at the dam is relatively high, and during winter, the lake level is often maintained at a decreased level where flow does not occur through the ladder. Adult salmonids are likely delayed in their upstream migration when the tide gate is closed and there is no flow through the ladder. This delay may result in increased predation by marine mammals. The primary species impacts of the tide gate and fish ladder are thought to be chum and steelhead which return during late-fall/winter when the lake level is reduced to the level where the fish ladder is not functioning.

Upstream anadromous access extends to Deschutes Falls, a natural waterfall at RM 41, which is a total upstream migration barrier. There are no other identified fish passage barriers on the mainstem Deschutes downstream of Deschutes Falls.

Substrate

Several assessments of substrate condition have been completed for segments of the mainstem Deschutes River and its major tributaries upstream of Vail that are within the anadromous zone. These include Schuett-Hames and Flores (1994), Schuett-Hames and Child (1996), both of which used TFW monitoring protocols and McNeil samplers, and Cramer (1997) which was based on pebble counts.

The Squaxin Island Tribe evaluated substrate composition in six reaches of the Deschutes River, one reach in Mitchell Creek, two reaches in Huckleberry Creek, one reach in Johnson Creek, and one reach in Thurston Creek (Schuett-Hames and Flores 1994). Within each reach, samples were taken at several riffles. The percent fines less than 0.85 mm were evaluated, due to the adverse impacts of fine sediment on salmon egg incubation. The data were compared to the TFW Watershed Analysis rating system, where fine sediment <12% is good (high survival predicted), 12-17% is fair (moderate and variable survival predicted), and >17% is poor (low survival predicted). The summary of data collected from this study is presented in Table 21. Of the eleven reaches evaluated, three were rated as good, six were rated as fair, and two were rated as poor. In some cases, elevated fine sediment levels were found downstream of large slide deposits. At least one of the reaches that was rated as good did not have any suitable spawning gravels because the bed was scoured down to cobble, boulders, and bedrock. Generally the Deschutes system above Vail was characterized as providing poor spawning conditions for salmonids due to elevated fine sediment levels.

In a separate study, the Squaxin Island Tribe evaluated substrate composition in five reaches of the mainstem Deschutes River (Schuett-Hames and Child 1996), one in the lower river (segment 36), two in the middle portion of the river (segments 31 and 28), and two upstream of Vail (segments 22 and 19). Sampling was done using TFW Monitoring protocols and a McNeil sampler. The data were also compared to the TFW Watershed Analysis rating system identified above. Summary data from this study are presented in Table 22. Of the five reaches, none rated good, one rated fair, and four rated as poor. These results indicate that spawning suitability and success appear to be compromised throughout the mainstem Deschutes River by high presence of fine sediments in the substrate.

Table 21: Spawning gravel fine sediment levels and Watershed Analysis rating for the Deschutes River system (from Schuett-Hames and Flores, 1994)

Stream	Gradient (%)	Avg. % fines <0.85 mm	Std. Dev.	Watershed Analysis Rating
Deschutes, Seg. 16	0.6	13.1	5.1	FAIR
Deschutes, Seg. 17	0.55	13.5	9.5	FAIR
Deschutes, Seg. 18	0.53	12.1	4.1	FAIR
Deschutes, Seg. 19	0.43	11.6	3.5	GOOD
Deschutes, Seg. 20	0.15	12.9	4.7	FAIR
Deschutes, Seg. 22	0.25	18.2	3.7	POOR
Mitchell, Seg. 1	2.0	9.6	4.0	GOOD
Huckleberry, Seg. 1	2.0	20.0	5.9	POOR
Huckleberry, Seg. 2	2.22	16.1	10.6	FAIR
Johnson, Seg. 1	1.94	13.4	5.4	FAIR
Thurston, Seg. 1	2.0	11.1	6.9	GOOD

Table 22: Spawning gravel fine sediment levels (<0.85 mm) and Watershed Analysis resource ratings for Deschutes River, 1995 (from Schuett-Hames and Child, 1996)

River	Seg. No.	River Mile	Gradient (%)	Avg. % fines <0.85 mm	Std. Dev.	Watershed Analysis Rating
Deschutes	19	33-35.7	0.40	15.5	4.5	FAIR
Deschutes	22	28.5-29.5	0.18	22.5	6.1	POOR
Deschutes	28	20.8-22.0	1.10	19.4	4.9	POOR
Deschutes	31	15.0-17.5	0.30	19.9	4.9	POOR
Deschutes	36	2.5-4.5	0.20	22.0	4.8	POOR

During the summers of 1996 and 1997, Thurston County conducted a reach scale analysis and habitat survey in the Deschutes River (Cramer, 1997) from Tumwater Falls Park to Deschutes Falls (RM 41). The river was segmented into 343 reaches. Substrate sediment was evaluated in each segment using the pebble count method, following guidelines in Leopold (1970, as referenced in Cramer 1997). The smallest particle size category was <4 mm. It is not possible to draw conclusions regarding the impact of fine sediment <0.85 mm from the pebble count data.

There is some information on the relationship of culverts and fine sediment in the forest management zone of the upper Deschutes watershed. A Weyerhaeuser report (Sullivan et al. 1987) identifies 1,097 culverts in the upper Deschutes watershed (1980 existing road network), including tributaries (Table 10), of which 391 (33%) had direct entry to streams. The drainage length encased in the 391 culverts draining directly to streams is 82,627 m. (51.6 miles). The data suggest a general relationship between road-use and increased turbidity in tributaries of the Deschutes River, but no quantitative relationship based on traffic rate could be established. Perhaps the single most important characteristic which determines the extent to which truck traffic affects water quality is the amount of the road surface in a basin which drains directly to streams. Turbidity also differed between watersheds as a function of differences in geology and from year to year as a function of rainfall (Sullivan et al. 1987). Turbidity can, however, can be significantly affected by specific discharge points in proximity to the channel, even though the overall road network may be low (McGreer and Heffner 1978 as reported in Sullivan et al. 1987). Bilby (1985) also documented the significant effect that one particular discharge point can have on sediment loading of a stream. He found that a single culvert in Johnson Creek, which drains an unusually large amount of road surface directly to the stream, contributed 21 percent of the total annual sediment load of the subbasin (Sullivan et al. 1987). Most of the sediment contributed from road runoff is fine sediment, which can clog spawning gravels. Fine sediment is identified as one of the key limiting factors in WRIA 13 streams that have been sampled. Because fine sediment is easily distributed throughout the watershed, efforts should be made to avoid additional fine sediment contribution to areas that are already adversely impacted by fine sediment load.

The origin of the sediment load in the Deschutes River is unclear. Collins (1994) concluded that erosion along the banks of the Deschutes was largely a natural phenomenon, was not unusually high, and has not significantly increased in the 50 year period of record that was reviewed. He also concluded that most of the sediment load to the lower river and Capitol Lake was originating from bank erosion sites in the lower river. Collins (1994) and Sullivan et al. (1987) estimated, however, that 17% of the suspended sediment in the Deschutes and 19% of the Capitol Lake sediment originated from the tributaries in the upper Deschutes. Other sources identify timber practices in the upper watershed as a significant source of sediment in the Deschutes. The Puget Sound River Basin Team (1990) identified timber practices as the principle controllable source of sediment in the river. Toth (1991) evaluated 76 road damage sites in the upper watershed following the January, 1990 floods. The most severe damage was typically related to older age roads and culverts. There was clearly a relationship between failures and roads. Of 38 landslides that were evaluated, 25 were road related and 23 (8 non-road related) resulted in delivery of the landslide to the stream, indicating an accelerated rate of sediment delivery to streams due to land use in the upper watershed.

Knowledge of potential impacts from fine sediment in spawning gravels is limited to those few stream segments in the WRIA where sampling has been completed. Available data indicate that fine sediment is of concern in most of the stream segments studied, and is identified as one of the key limiting factors in the Deschutes River. Substrate sampling is recommended in additional streams and stream segments to determine to what extent fine sediment in spawning gravels may be a limiting factor in the Deschutes watershed.

There is good spawning habitat on the mainstem Deschutes between the mouth of Spurgeon Creek and Offut Lake outlet that warrants special consideration for protection.

Floodplains

Most of the Deschutes River below Deschutes Falls (RM 41.0) flows through unconsolidated silt, sand, and gravel deposited by the last continental glaciation. Consequently, the watershed is only about 12,000 years old and is still in the process of building its floodplain by undercutting glacial terraces that exist throughout the middle and lower basin. Upstream of Deschutes Falls (RM 41) the river flows through primarily weathered volcanic rock with steep straight slopes focused into narrow V-shaped valleys (Collins 1994).

Floodplain Connectivity. Dikes, levees, and other floodplain constrictions were not identified as a habitat limiting factor or concern in the Deschutes River. The FEMA designated 100-year floodplain and active meander zones have been mapped on ortho-photos of the Deschutes River below Deschutes Falls (Appendix 2). It is important to note, however, that river meanders and identified flooding have been observed outside the identified floodplain at numerous locations in the watershed. Of the approx. 602 acres identified in the meander belt area, 540 acres are inside the 100-year floodplain, 10 acres are in the 500-year floodplain, and 52 acres are outside the floodplain (Cramer 1997).

Streambank Stability. The most complete data available on streambank stability are found in the Deschutes River Reach Scale Analysis and Habitat Survey (Cramer, 1997). Active channel bank erosion was evaluated for each bank in each of 343 reaches from Tumwater Falls (RM 1.9) to Deschutes Falls (RM 41.0). Table 23 presents a summary of the streambank erosion data.

Table 23: Length of active bank erosion on the Deschutes River (from Cramer, 1997). Data reflects number of miles (total sample length of 38.1 miles) exceeding designated erosion rate

Erosion Rate	**Left Bank**	**Right Bank**	**Both Banks**
>20%	28.85	24.52	14.57
>50%	21.11	16.92	5.86
>75%	15.36	12.94	2.35

Bank erosion and channel migration have been hot button issues in the Deschutes Basin for a number of years (Cramer, 1997). It is clear from the reach data that active bank erosion is common throughout the Deschutes mainstem. Within the sample area, approximately 75% of the left bank and 65% of the right bank had bank erosion exceeding 20%. Thirty eight percent of the sample area had bank erosion exceeding 20% on both banks. The Wild Salmonid Policy identifies bank erosion rates >10% as being detrimental to salmonids. Bank erosion >10% contributes to channel instability, substrate aggradation and scour, and elevation of fine sediment levels in the channel substrate. Even with well developed, mature riparian stands, it is thought that channel erosion would be common due to the Deschutes being a geologically “young” watershed (Cramer 1997, Collins 1994). Erosion was found on banks with and without mature riparian vegetation. Significantly eroding banks did have a higher occurrence of fine grained, unconsolidated sands and silts than the reaches with non-significant erosion. Mature riparian vegetation existed in more than 50% of the reaches where bank erosion exceeded 60%. The study did not consider the rate of erosion, only the occurrence of erosion. It is important to remember that mature riparian vegetation is important to develop and protect, since mature riparian buffers tend to slow the rate of channel migration on banks less than three meters high (>90% of banks in study area). Human modification did not correlate well with the occurrence of significantly eroding banks. However, field observation did appear to indicate a high occurrence of erosion on banks downstream of rip-rapped banks and extremely active sloughing of banks that had been cleared for pasture (Cramer, 1997).

Cramer’s (1997) conclusions suggest that local channel characteristics at the reach level do not appear to be the driving force causing channel erosion and migration. This agrees with Collins (1994) findings that the dominant influences on the rates and locations of eroding banks are geologic and topographic. Mainstem channel erosion occurs more often downstream of a coarse sediment source, where the channel is not confined and gradient is declining. This is common among glaciated lowland river valleys in the Northwest. Rivers in these conditions tend to erode more sediment from their mainstem than is transported in from the headwaters as they incise and widen their floodplains into the glacial terraces (Collins 1994).

Human manipulation of banks was found to be high in the Reach Scale Analysis (Cramer 1997). This typically represents rip-rapping, artificial armoring, removal of riparian overstory, or other disturbance of natural bank characteristics. Table 24 provides summary data for Human Manipulation. Within the sample area, 36% of the left bank and 32% of the right bank have been altered by human manipulation. Twenty one percent of the river length in the sample area has been altered on both banks.

Table 24: Length of river bank that has been altered by human manipulation (total sample length of 38.1 miles, Source - Cramer 1997)

Bank Manipulation Threshold	Left Bank (miles)	Right Bank (miles)	Both Banks (miles)
>20%	13.85	12.30	8.04
>50%	10.64	9.79	5.97
>75%	8.82	8.38	4.63

Slowing or stopping channel erosion of glacial terraces is probably not practical. The river is intent on reclaiming these terraces and widening its floodplain, which in the long run could have a stabilizing effect on the channel. Allowing the river to widen its floodplain can result in greater energy dissipation of peak flows and tends to increase habitat complexity (Cramer 1997).

Large Woody Debris (LWD). Assessment of LWD has been done for the mainstem Deschutes River (Cramer 1997, Schuett-Hames and Child 1996). Both of the studies on the mainstem Deschutes River had comparable findings. Schuett-Hames and Child (1996) assessed LWD in five mainstem segments. The LWD piece count was rated as good in each of the five segments, but each of the segments rated poor in relation to the presence of key piece LWD (pieces with volumes >9 meters^3). Similar findings resulted from the Reach Scale Analysis (Cramer1997) which reported 59% of the reaches with >2 pieces of LWD per bankfull width (good), 30% of the reaches with 1-2 pieces of LWD per bankfull width (fair), and 12% of the reaches with <1 piece LWD per bankfull width (poor). Cramer also reported few large logs (>50 cm (20 in.) diameter). Most of the few large logs were part of debris jams. He reported the majority of woody debris (89%) in both debris jams and individual pieces consisted of small and medium sized logs. Small and medium sized logs are not very stable and probably not effective at creating habitat in the Deschutes River. Field observations during the survey appeared to concur with the findings of Bilby (1985), that individual pieces need to be >50 cm in diameter and 10 meters in length to have stability in a channel with a bankfull width >15 meters. Cramer indicates that for an individual log to be stable and function as habitat in the Deschutes River, it would probably have to be >70-75 cm (30 in.) in diameter and 12-15 meters (40-50 ft.) in length.

Available data indicate that the Deschutes River is deficient in large, key piece LWD. These, LWD components are necessary to create functional, diverse, and stable salmonid habitat. Unfortunately, riparian stands have been altered along much of the river, eliminating the near-term recruitment potential for LWD, and particularly key piece sized LWD. It will likely be necessary to develop an interim LWD supplementation strategy until a longer-term riparian recovery strategy results in equilibrium recruitment of LWD to the river and tributaries.

Presence of Pools. Pools are an integral component of salmonid habitat, providing rearing habitat for juvenile salmonids and resting and cover for adults on their upstream spawning migration.

Evaluation of pools in the mainstem Deschutes River was conducted as part of the Reach Scale Analysis (Cramer 1997).

Data from the Deschutes River Reach Scale Analysis (Cramer 1997) indicate >50% of the reaches had >55% pools at low flow (good), 17% of the reaches had 40-55% pools (fair), and 27% of the reaches had <40% pools (poor). Pool habitat did not rank as well when considering the number of bankfull widths per pool or pool frequency. Forty–seven percent of reaches had >4 bankfull widths per pool (poor), 29% of the reaches had 2-4 bankfull widths per pool (fair), and 24% of the reaches had <2 bankfull widths per pool (good). Residual pool depth varied from 0.4 to 4.0 meters (1.3-13 ft.)(Cramer 1997). This study may present a more positive pool condition than actually exists. The river was only identified to riffles or pools. Much of the identified pool habitat is thought to actually be long non-complex runs with sufficient depth that classified them as pools. This also appears to be consistent with the lack of LWD throughout the mainstem. This condition would negate much of the rearing benefit and value, particularly for species such as coho and cutthroat, associated with typical pool habitat.

Off-Channel Habitat. Cramer (1997) found that 72% of the 343 reaches surveyed had little or no off-channel rearing availability, 17% of the reaches ranked medium, and only 11% ranked high. Off-channel habitat is essential to the life history of several salmonid species, providing stable habitat for spawning and rearing, and providing refuge for adult and juvenile salmonids during peak flows. Historically, off-channel habitat in the Deschutes is thought to have been more prevalent. Subsequent to the Reach Scale Analysis, the Squaxin Tribe has mapped off-channel habitat areas and is in the process of prioritizing them for protection and restoration funding. Mapped off-channel habitats are identified on the floodplain maps in Appendix 2. It is recommended that existing off-channel habitat information be supplemented with additional field surveys, concentrating first on the area between Offut Lake and Lake Lawrence.

Riparian Buffer Width

Historic natural riparian buffers in the Deschutes River watershed, including tributaries, typically would have been a mature conifer stand, including cedar, Douglas fir, and hemlock, with understory presence of deciduous species. Riparian vegetation provides a number of functions critical to a healthy watershed, including shade, cover, improved water quality, leaf litter to help support the aquatic food chain, and large wood to the channel to provide channel complexity and key habitat niches. Unfortunately, many of these functions are significantly compromised in the Deschutes River due to the lack of functional riparian zones. Riparian vegetation has been altered over time, typically associated with the adjacent land use. Vegetation has been removed for the value of the timber, to facilitate views and access to the river, as well as providing alternate land use, such as grazing and agriculture. Riparian buffer disturbance and removal has occurred in all land use categories, urban and suburban, agriculture, and forest management.

The Wild Salmonid Policy (WDFW and WWTIT 1997) recommends a buffer of mature conifers the width of one site-potential tree height (the height of the tallest dominant or co-dominant native tree that would naturally grow on the soils present at the site) to provide the functions important to salmonids. Wide riparian buffers are important to minimize stream bank erosion, provide shade, provide cover, maintain water quality, and provide LWD to the channel. They are particularly important where the stream or river is located in a broad floodplain, to minimize the potential of major channel changes within the river meander zone. Riparian function is compromised when buffers are narrower than the functional width or where the buffer vegetation has been altered and historical conifer presence has been replaced with deciduous trees. Conifer are of particular importance because of their contribution of large wood to the stream channel, which creates the instream habitat diversity important to salmonids.

Riparian vegetation status was evaluated as part of the Deschutes River Reach Scale Analysis (Cramer 1997). Table 25 provides summary data of the length of each bank that had riparian buffers within the designated widths. Within the sample area, only 2% of the left bank area, 5% of the right bank area, and 1% of both banks had estimated riparian widths >30 meters. Thirty meters is considered to be the minimum riparian width necessary to provide important riparian functions. The other component that was evident from the riparian data was the paucity of conifer in the riparian vegetation, which are necessary to provide durable LWD as well as other functions.

Table 25: Length of banks on the Deschutes River where riparian buffers exceed the designated widths (total sample area was 38.1 miles, Source - Cramer 1997)

Riparian Buffer Width (m)	**Left Bank (miles)**	**Right Bank (miles)**	**Both Banks (miles)**
<10	14.38	13.40	8.92
10-30	13.84	13.30	8.01
>30	.90	1.87	.51

[Note: Many records in the database did not have riparian buffer width identified. A high proportion of records with 10-30 m. buffers are estimated at 10 m. Data in table reflects only buffer width and not type of vegetation.]

Impaired riparian function is evident in other components of the Reach Scale Analysis (Cramer 1997) and work by the Squaxin Island Tribe (Schuett-Hames and Child 1996) which document low canopy closure, water temperatures exceeding the State Water Quality Standards threshold, lack of large wood, and other factors associated with riparian buffers. Lack of canopy cover was also noted by the Squaxin Island Tribe (1991) in sections of Huckleberry, Buck, and Ware creeks, all tributary to the upper Deschutes River.

Water Quality

Capitol Lake, located at the mouth of the Deschutes River and Percival Creek, is an area through which all juvenile salmonid outmigrants and all returning adult salmonids must pass. There are a number of water quality concerns in Capitol Lake, but information on the effects to juvenile and adult salmonids is limited. Capitol Lake is on the 303(d) list for high fecal coliform counts (from livestock, septics, stormwater and waterfowl) and high total phosphorous (which triggers algal blooms). In addition, other water quality concerns have been identified, including low dissolved oxygen (resulting from algal blooms), high temperature (from limited exchange and circulation), and high turbidity (from upstream bank erosion during peak flows)(Entranco 1998). Several of these elements are likely exacerbated by similar water quality concerns in the contributing waters from the Deschutes River. These concerns, except for the high fecal coliform counts and turbidity typically manifest themselves during the warm periods of mid to late summer, with associated effects to any chinook, coho, or steelhead juveniles rearing in Capitol Lake or Percival Cove or to adult chinook returning to the Deschutes River or Percival Creek. Further study is warranted to identify the water quality effects to juvenile and adult salmonids.

Water quality on the Deschutes mainstem is also impaired. The Deschutes is on the 303(d) list for high fecal coliform (attributed to agricultural activity), high temperature (typically associated with absence/loss of riparian shading), and pH (probably from natural conditions)(Barecca 1998). It was also previously listed for mercury, which was proposed for removal from the listing in 1998. All of these water quality concerns, except fecal coliform, are known to adversely affect salmonids, but the magnitude of effect is unknown.

The stream is also known to carry a very high fine sediment load during peak flows. High rates of bank erosion are thought to be normal in the watershed, but opportunities exist to reduce erosion and sediment load by restoring mature riparian zones along areas of the river with shorter banks, and controlling timber-related erosion in the headwaters (Barecca 1998).

Water Quantity

The Deschutes River is on the 303(d) list for instream flow concerns. The Deschutes watershed has an established rule (Chapter 173-513 WAC, 1980) that applies to waters within the Deschutes River basin for the purpose of retaining perennial rivers, streams and lakes in the basin with instream flows and levels necessary to provide protection for wildlife, fish, scenic, aesthetic, environmental values, recreation, navigation, and water quality. Instream flows and closures for the Deschutes River from the confluence of the river with Capitol Lake upstream to Deschutes Falls (RM 41) are presented in Table 26.

Table 26: Established minimum instream flows and water allocation closures in WRIA 13 (Source, Chapter 193 WAC)

Stream or River	Instream Flow Req./Closure
Deschutes River blow Deschutes Falls	
December 15 – March 31	400 cfs.
April 1 - April 14	350 cfs.
April 15 – October 31	Closed
November 1 – November 14	150 cfs.
November 15 – November 30	200 cfs.
December 1 – December 14	300 cfs.
Percival Creek	Closed
Woodland Creek	Closed
Adams Creek	Closed
Woodard Creek	Closed
Green Cove Creek	Closed
McLane Creek	Closed

Flows are typically lowest in late summer and impact juvenile salmon (coho) and steelhead rearing in the watershed, adult salmon (most likely chinook) migrating and spawning in the river, and resident trout. U.S. Geologic Survey (USGS) flow data collected at RM 3.4 between 1990 and 1995 are consistently below minimums established in WAC 173-513-030 (DOE Section 303(d) list) and not adequate for salmon. Further study is warranted to determine the extent of impact of low instream flow to juvenile and adult salmonids. Water quantity concerns should be actively considered by the HB 2514 Watershed Planning Unit to ensure that current instream flow requirements afford protection to salmonids, and to ensure that appropriate instream flows are achieved.

Estuarine

Salmonids have naturally adapted to conditions that provide a brackish or lower salinity transition zone between fresh and salt water. This allows salmonids to gradually adapt on their juvenile migration to saltwater and on their adult migration back to fresh water. The estuary in the southern portion of Budd Inlet has been significantly altered by diking and associated freshwater retention in Capitol Lake. The natural estuary historically extended upstream to the base of Tumwater falls. This would also have created a natural estuary at the mouth of Percival Creek. However, prior to the introduction of salmon into the Deschutes system, Capitol Lake was formed by diking off the estuary at 5th Avenue in Olympia and installing a tide gate to allow the area upstream to be maintained as freshwater. This action removed all of the area occupied by Capitol Lake from the natural estuary, and established a much more abrupt change from fresh to saltwater. The low salinity zone in Budd Inlet was moved downstream to just below the tide gate. Juvenile and adult salmonids in the Deschutes/Percival system must now negotiate a more direct transfer from fresh to salt water, and vice versa, than would have occurred under natural estuarine conditions. However, it must be remembered that the creation of Capitol Lake actually occurred prior to the introduction of salmonids to the Deschutes River, and the only salmonids that experienced a decrease in estuarine area from historic conditions are those originating from Percival Creek and other tributaries to Budd Inlet.

Please refer also to the habitat limiting factor estuarine summary section earlier in this report for a discussion of the impacts of alteration or loss of shallow nearshore substrate, which affects salmonids from the Deschutes as well as other streams within WRIA 13.

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- fix the Capitol Lake tide gate to ensure fish passage at all lake and tidal levels,
- conduct a Watershed Analysis in the upper watershed with particular focus on slope stability, road impacts (density and sedimentation), and culverts,
- further characterize and resolve fine sediment and water quality problems in the lower river,
- restore mature coniferous riparian zones (site potential tree height) throughout the watershed, including full protection of the channel meander zone,
- support bank protection efforts that restore channel and riparian function; avoid expenditure of funds to try to stop natural channel erosion of glacial terraces,
- develop and implement a strategy to place LWD, particularly key-piece sized pieces and/or log jams, through the interim period until restored riparian zones are capable of natural contribution of LWD,
- field verify off-channel habitat maps and protect/enhance high priority areas, and
- forward instream flow concerns to WRIA 13 HB 2514 Watershed Planning Unit.

Percival Creek 13.0029 and Black Lake Ditch 13.0030

The key habitat factors (not prioritized) limiting salmonid production in Percival Creek and Black Lake Ditch are:

- juvenile and adult fish passage at the Percival Cove screen,
- fish passage at the Capitol Lake tide gate,
- altered hydrology,
- water quality effects (elevated temperature and phosphorous-induced algal blooms leading to reduced DO) in Capitol Lake,

- elevated summer temperature and lack of LWD in upper Percival and Black Lake Ditch,
- limited gravel availability in upper Percival and Black Lake Ditch, and
- altered estuary conditions.

These factors are discussed in the following descriptions of specific habitat factors.

Fish Passage

Adult salmonids are impacted at the Capitol Lake tide gate by impaired function of the fish ladder. Tidal water is not allowed to flow freely into the lake, and the lake level is maintained within a narrow range. A fish ladder was installed to provide passage for salmonids at varying tidal stages. Chinook are also known to enter the lake through the tide gate opening under certain conditions. The entrance to the fish ladder at the dam is at elevation 5.0 ft. MSL, but is not operational until the lake is above elevation 5.5 ft. MSL. During winter, the lake level is maintained at an elevation of 5.4 ft. MSL to provide for additional flooding protection to downtown Olympia. However, this elevation does not allow adult salmon to use the ladder (Darin Cramer, personal communication). Adult salmonids are likely delayed in their upstream migration when the tide gate is closed and there is no flow through the ladder. This delay may result in increased predation by marine mammals. The species primarily affected by the tide gate and fish ladder are thought to be chum and steelhead, which return during late-fall/winter when the reduced lake level impairs proper function of the fish ladder.

Migration of juvenile and adult salmonids from and to Percival Creek is impaired by the installation and operation of a screen at the outlet of Percival Cove adjacent to Deschutes Parkway. The timing of juvenile and adult screening has been reduced over the last 20 years, but still occurs in a manner that significantly affects natural salmon production in Percival Creek. A fine-meshed screen is installed from approx. April 1 through May 15 to retain Age 0 and yearling chinook that are being reared by WDFW in Percival Cove. On May 15 the screens are removed, allowing the reared chinook and other anadromous salmonids to emigrate from Percival Cove. It is likely, however, that much of the natural juvenile salmon and steelhead production attempting to migrate from Percival Creek may either be delayed in their migration, or may actually fall prey to the chinook yearlings being actively reared in Percival Cove. Either fate will adversely affect survival. Returning adult salmon (chinook) are also impaired in their ability to migrate freely to Percival Creek. Pickets (spaced approx. 1.5 inches) are installed approx. August 10 and not removed until September 30. The intent is to maximize the return of adult chinook to the hatchery facility at Tumwater Falls, but this effort does affect the timing and magnitude of chinook return to Percival Creek.

The Fish Barrier Database (SSHEAR 1999) identified three road crossings on Percival Creek and one road crossing on Black Lake Ditch (Mottman Rd.) as fish passage barriers (Table 9). The barriers on Percival Creek at Mottman Rd. and Chapparal Rd. have been repaired, leaving the Sapp Rd. culvert as the only remaining barrier (partial) on Percival Creek.

Floodplains

The main floodplain alteration in this basin is associated with the Black Lake Ditch. This area historically existed as a broad wetland with no clearly defined channel. Some drainage from Black Lake to Percival Creek occurred, but the primary drainage from Black Lake was to the Black River in the Chehalis basin. Black Lake Ditch was dredged with the intent to channel the majority of the outlet drainage from Black Lake to Percival Creek. Although the Black Lake

Ditch drainage remains a wetland, it is likely that the surrounding water table may have degraded due to the dredging of the ditch, and that surface flow, which historically was dispersed across the wetland, is now more confined in the ditch. The ditch also lacks sinuosity.

Presence of LWD. Watershed data from Chris May (1999) indicating LWD status are referenced in Table 27.

The data indicate low LWD presence in upper Percival and Black Lake Ditch. The percentage of LWD that is coniferous, and therefore more durable, is generally low throughout, but of particular concern in upper Percival and Black Lake Ditch. LWD recruitment potential is low except in middle Percival.

Table 27: LWD estimates for reach sample sites in Percival Creek and Black Lake (May 1999)

	LWD Volume m^3/km	LWD Volume m^3/LWD	% Pools LWD-Formed	% LWD Coniferous	% LWD >0.5 m Dia.	LWD Recruitment Potential
Lower Percival	318	3.8	67	48	55	Fair
Middle Percival	226	1.4	78	44	39	Optimal
Upper Percival	42	1.0	45	31	22	Poor
Black Lake Ditch	9	0.7	18	22	18	Poor

Stability of Banks - May (1999) estimates bank stability as >75% stable for lower Percival and 25-50% stable for middle Percival.

Presence and Condition of Pools. Watershed data from Chris May (1999) estimate percent pool habitat as 36% in lower Percival, 39% in middle Percival, 24% in upper Percival, and 15% in Black Lake Ditch. All of these values are significantly below the functional threshold recommendations in the Wild Salmonid Policy of 55% pool habitat for streams <15 meters wide and <2% gradient.

Substrate

Observations by WDFW and others in the upper watershed have noted a very limited supply of gravel in the upper watershed and in Black Lake Ditch. Spawning in these areas is limited to those few areas where gravel deposits occur. Limited substrate sampling data are available for this basin. May (1999) estimated embeddedness of gravel in riffles in lower and middle Percival Creek, with values of 40% and 30% respectively. This is also supported by Intergravel Dissolved Oxygen (IGDO)/Dissolved Oxygen (DO) ratio estimates of 62% for lower Percival and 75% for middle Percival (ratios should be >80% to indicate functional exchange of surface water through the gravel). May (1999) conducted benthic invertebrate sampling to generate a Benthic Index of Biotic Integrity (B-IBI) estimate of 31 for lower Percival and 23 for middle Percival.

Riparian Condition

Watershed data from May (1999) estimate canopy cover at 64% in lower Percival, 95% in middle Percival, 33% in upper Percival, and 21% in Black Lake Ditch. The riparian buffer quality was rated as fair in lower Percival, functional in middle Percival, poor in upper Percival, and non-functional in Black Lake Ditch. Recommendations in the *Percival Creek Basin – Olympia and Tumwater, Washington. Current and Future Conditions* include active management of riparian areas, with regard to both current and future riparian functions and woody debris recruitment. Protecting riparian buffers and keeping development out of riparian areas is also recommended.

Water Quality

Urban stormwater conveys heavy fine sediment (see substrate concerns), as well as oil and gas contaminated runoff. Stormwater from Highway 101 and the Capitol Auto Mall also drain to Percival Creek. Black Lake Ditch conveys degraded water (high temperature and high biochemical oxygen demand) from Black Lake into the system. *The Percival Creek Comprehensive Drainage Basin Plan* recommends improvement of stormwater treatment facilities (a large stormwater facility has been constructed in Black Lake Ditch to treat flow from Cooper Point) and implementation of pollution source control programs. Further study is warranted to identify the water quality effects to juvenile and adult salmonids. Adult and juvenile salmonids are likely affected by water quality in Capitol Lake. Please refer to the discussion of Capitol Lake water quality concerns in the discussion of habitat limiting factors for the Deschutes River.

Water Quantity

The primary threat to salmonids in the Percival Creek/Black Lake Ditch watershed is considered to be alteration of natural hydrology. The hydrology has been altered by development in the basin and by altering the majority of runoff from Black Lake from the Chehalis basin to Percival Creek. Watershed data from Chris May (1999) estimate impervious surface at 21.8% for lower Percival, 12.4% for middle Percival, 11.1% for upper Percival, and 24% for Black Lake Ditch. Generally, alterations to natural hydrology peak flow magnitude and frequency are observed as impervious surface exceeds 3-5% and significant impacts occur as impervious surface exceeds 10%. This is exacerbated by the routing of increased flow from Black Lake to Percival Creek. The *Percival Creek Comprehensive Drainage Basin Plan* recommends improvement of stormwater conveyance and storage facilities as well as improvement of drainage regulations and development controls (a large stormwater facility has been constructed in Black Lake Ditch to treat flow from Cooper Point).

Estuarine

Salmonids have naturally adapted to conditions that provide a brackish or lower salinity transition zone between fresh and salt water. This allows salmonids to gradually adapt on their juvenile migration to saltwater and on their adult migration back to fresh water. The estuary for the Deschutes River and Percival Creek has been dramatically altered by the damming of Capitol Lake with a dam and tide gate. The damming of Capitol Lake eliminated the brackish estuary areas that would have been in the tidally influenced zone. Juvenile salmonids now must pass directly from fresh water to salt water at the dam site under 5th Avenue, and adult salmonids must move directly from salt water to fresh water on their return to the Deschutes River and Percival Creek. The impacts associated with this altered condition, particularly to juvenile outmigrants, are unknown at this time. Adult salmonids are observed to mill in the south end of Budd Inlet in the Capitol Lake outflow immediately downstream of the tide gate. During this milling, adult salmonids are exposed to increased predation from marine mammals frequenting the area. Please also refer to the discussion of estuarine concerns in the discussion of habitat limiting factors for the Deschutes River.

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- incorporate Sapp Road culvert partial fish barrier correction into WRIA 13 restoration project prioritization, based on assessment of upstream habitat benefit to salmonids; correction, should involve replacement of the culvert rather than retrofitting,
- fix Capitol Lake tide gate to ensure fish passage at all lake and tidal levels,
- evaluate flow impacts (quantity and quality), from Black Lake through Black Lake Ditch, and determine whether modifications are warranted,
- identify and correct adverse impacts to naturally produced adult and juvenile salmonids resulting from the Percival Cove screen,
- prioritize new stormwater facilities to resolve current stormwater impacts, and prevent further impacts from construction of new impervious surface,
- protect riparian zones that are currently in good condition and restore riparian function in areas that have been degraded, and
- evaluate condition and production/restoration potential of instream habitat in upper watershed.

Unnamed 13.0032

No information on habitat limiting factors was identified by the TAG for this stream.

Chambers Creek 13.0033 and Chambers Ditch 13.0034

The habitat limiting factors identified for Chambers Creek and Chambers Ditch are the lack of riparian vegetation and the lack of spawning gravel (Thurston County 1995). Chambers Ditch is reported to have no surface flow from May to October (Andy Haub, personal communication), and low summer flows in Chambers Creek are also noted as limiting the amount of habitat available for rearing. Thurston County found fecal coliform bacteria levels that exceeded standards in Chambers Creek (Thurston County 1992-1998).

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- restore functional riparian buffers,
- refer low flow concerns to WRIA 13 HB 2514 Watershed Planning Unit for resolution, and
- identify and correct fecal coliform sources.

Ayer (Elwanger) Creek 13.0036

Ayer (Elwanger) Creek is significantly impaired due to agricultural impacts; riparian condition is poor, and the substrate is comprised almost entirely of fine sediment (Darin Cramer, personal communication). In addition, Ayer Creek is on the 303(d) list for low dissolved oxygen, pH, and fecal coliform. Thurston County considered Ayer and Reichel creeks to have the poorest water quality of the Deschutes River tributaries (Barecca 1998).

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- restore functional riparian habitat, and

- identify sources of fecal coliform, and correct, and
- address remaining agricultural activities that are causing adverse physical habitat and water quality impacts to salmonids.

Spurgeon Creek 13.0037

Spurgeon Creek is significantly impaired due to agricultural impacts; riparian condition is poor, there is direct livestock access to the channel, associated wetlands have been converted to agricultural use, and the substrate is comprised primarily of sand (Darin Cramer, personal communication). Culverts at four road crossings have been assessed for fish passage and determined to not be barriers at the time the assessment occurred. Thurston County found fecal coliform bacteria levels that exceeded standards in Spurgeon Creek (Thruston County 1992-1998).

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- restore functional riparian habitat,
- identify benefits and potential of associated wetlands restoration,
- identify sites with unrestricted livestock access to the channel, report to Thurston County Health Department for correction, and
- address remaining agricultural activities that are causing adverse physical habitat and water quality impacts to salmonids.

Offut Lake Outlet 13.0040

No information on habitat limiting factors was identified by the TAG for this stream. The culvert under Offut Lake Rd. is identified in the Fish Passage Barrier Database (SSHEAR 1999) as a barrier to fish migration. Salmon and steelhead are currently precluded from accessing habitat in Offut Lake by presence of a fish screen at the outlet of the lake; the merits of this screen warrant further evaluation.

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- prioritize and correct identified fish passage barriers, and
- evaluate the merits of providing fish passage at the outlet of Offut Lake.

Silver Springs Creek 13.0041

No information on habitat limiting factors was identified by the TAG for this stream. Presence of beaver dams at mouth may limit salmonid access (Darin Cramer, personal communication), although beaver dams are typically considered beneficial to salmonid habitat. Special protection consideration is warranted for existing spring-fed off-channel habitat between Offut Lake and McIntosh Lake.

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- identify the extent of high quality spring-fed off-channel habitat and available options to ensure long term protection.

Unnamed 13.0042

No information on habitat limiting factors was identified by the TAG for this stream.

Unnamed 13.0045

No information on habitat limiting factors was identified by the TAG for this stream. The Fish Passage Barrier Database (SSHEAR 1999) includes references to culverts on two tributaries to this unnamed stream. One of the culverts, under 153rd Avenue is identified as a barrier to fish migration.

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- prioritize and correct identified fish passage barriers.

Reichel Creek 13.0046 and Unnamed 13.0047

Reichel Creek is on the 303(d) list for high fecal coliform. Temperatures above state standards were found in Reichel Creek. Thurston County considered Ayer and Reichel creeks to have the poorest water quality of the Deschutes River tributaries (Barecca 1998). The Fish Passage Barrier Database (SSHEAR 1999) identifies the culvert on Unnamed 13.0047 at Chatwood Rd. as a barrier to fish migration. The channels are impaired by agricultural activities, including direct animal access to the creeks, and lack of functional riparian zones. The creek is also impacted by run-off from a former log sort yard in the headwaters, which discharges fine sediment and heavy machinery associated contaminants to the creek (Darin Cramer, personal communication).

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- prioritize and correct identified fish passage barriers,
- identify sites with unrestricted livestock access to the channel, report to Thurston County Health Department for correction,
- address remaining agricultural activities that are causing adverse physical habitat and water quality impacts to salmonids, identify and address continuing runoff problems associated with the former log sort yard; implement appropriate in-channel mitigation and restoration, and
- restore functional riparian buffers throughout drainage.

Pipeline Creek 13.0051, Unnamed 13.0052, and Hull Creek 13.0053

No information on habitat limiting factors was identified by the TAG for these streams.

Fall Creek 13.0057

No information on habitat limiting factors was identified by the TAG for this stream. The Squaxin Island Tribe (1991) identified reach F4 as having bank-cutting rates of over 500 meters of raw bank/1000 meters of stream.

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- restore and maintain functional mature native woody vegetation in riparian buffers and on unstable slopes to minimize the rate of landslides and active bank erosion.

Unnamed 13.0066

No information on habitat limiting factors was identified by the TAG for this stream.

Mitchell Creek 13.0069

Mitchell Creek is the largest tributary in the upper Deschutes basin, representing 15% of the upper basin drainage area. Moore and Anderson (1979) found that Mitchell Creek transported the greatest amount of sediment of the tributaries in the upper watershed, contributing approximately 19% of the total load of the river above the Weyerhaeuser 1000 Road. The Squaxin Island Tribe (1991) identified reach V4 as having bank-cutting rates of over 500 meters of raw bank/1000 meters of stream. Rates of mass wasting in excess of 1000 $ft.^2$/1000 meters of stream occurred in reaches V1-1 and V2 and in three reaches of a tributary. LWD concentrations were found to be low in the Squaxin Island Tribe study, which may also affect the ability of the stream to retain gravel suitable for spawning.

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- restore and maintain functional mature native woody vegetation in riparian buffers and on unstable slopes to minimize the rate of landslides and active bank erosion, and
- develop and implement an interim strategy to supplement key piece LWD in the creek until restored riparian habitat is capable of contributing functional LWD.

Huckleberry Creek 13.0086

Channel instability, bank erosion, presence of fines in the substrate, lack of canopy cover, and lack of LWD below the debris flow are key limiting factors in this drainage. Approximately 10% of the coho production in the Deschutes River watershed originated from Huckleberry Creek prior to a debris flow in January, 1990, which affected much of its length. The debris flow significantly altered channel productivity. The Squaxin Island Tribe (1991) identified that the channel upstream of the debris flow had approximately a 50% pool:50% riffle ratio, while cascades dominated the area below. The channel below the debris flow is aggrading. There were 16% fines (fair) in the substrate above the debris flow, and 20% (poor) in the substrate below the debris flow. Several segments lacked the necessary canopy cover; three segments had bank-cutting rates of over 500 meters of raw bank/1000 meters of stream; one segment had rates of mass wasting in excess of 1000 $ft.^2$/1000 meters of stream. LWD presence was the highest of any reach upstream of the debris flow, but limited below.

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- restore and maintain functional mature native woody vegetation in riparian buffers and on unstable slopes to minimize the rate of landslides and active bank erosion, and
- develop and implement an interim strategy to supplement key piece LWD in the creek until restored riparian habitat is capable of contributing functional LWD.

Johnson Creek 13.0089

Bank erosion, lack of LWD, and presence of fines in the gravel are key limiting factors in this drainage. The Squaxin Island Tribe (1991) identified one reach (M1) with over 500 meters of raw bank/1000 meters of stream, low levels of LWD, and one reach (SEG 1) as having 13% fines (fair, although just over the 12% level that would be considered good).

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- restore and maintain functional mature native woody vegetation in riparian buffers and on unstable slopes to minimize the rate of landslides and active bank erosion, and
- develop and implement an interim strategy to supplement key piece LWD in the creek until restored riparian habitat is capable of contributing functional LWD.

Thurston Creek 13.0095 and Unnamed 13.0097

Bank erosion and lack of LWD are the key limiting factors in this drainage. The Squaxin Island Tribe (1991) identified two reaches (M1 and V2) with over 500 meters of raw bank/1000 meters of stream and generally low levels of LWD.

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- restore and maintain functional mature native woody vegetation in riparian buffers and on unstable slopes to minimize the rate of landslides and active bank erosion, and
- develop and implement an interim strategy to supplement key piece LWD in the creek until restored riparian habitat is capable of contributing functional LWD.

Unnamed 13.0102

No information on habitat limiting factors was identified by the TAG for this stream.

Unnamed 13.0104

A mass failure at a Thurston County site is contributing fine sediment to the Deschutes mainstem. Further evaluation of potential restoration options is warranted.

Schneider Creek 13.0131

Altered hydrology has significantly changed habitat in Schneider Creek. Data on several habitat parameters were collected by Chris May (1999). The total impervious surface was estimated at 42.2%,and remaining forest cover is estimated at only 11.5%. Road densities are estimated at 9.4 km/km^2. Approximately 71% of riparian buffers were estimated to be greater than 30m. wide, and 21% estimated to be less than 10 m. wide. Riparian vegetation is described as young deciduous, with approximately 70% canopy cover. LWD was estimated at 0.7/bank full width, with 82% >0.5 m. diameter, 82% within the bank full width, and 51% of the LWD being conifer. The abundance of pool habitat was low (24%), with 66% of the stream being riffle habitat. This is significantly less than the threshold for functional pool habitat identified in the Wild Salmonid Policy, which is 55% pools for streams <15 meters wide. The intergravel dissolved oxygen (IGDO)/ dissolved oxygen (DO) ratio was estimated at 0.61, well below the 0.8 level, which is the lower limit of good quality spawning habitat. The B-IBI score for Schneider Creek was 25, which is on the bottom end of the moderate ranking. Both the IGDO/DO and B-IBI scores indicated significantly impaired spawning and rearing substrate. Bank stability is poor, with 25% of the banks being stable. Thurston County found fecal coliform levels that exceeded state standards in Schneider Creek (Thurston County 1992-1998).

Action Recommendations – The following salmonid habitat restoration actions are recommended:

- develop and implement stormwater control measures to restore natural hydrology,

- restore and maintain functional riparian buffers, including conversion from deciduous to conifer,
- develop and implement an interim strategy to supplement key piece LWD in the creek until restored riparian habitat is capable of contributing functional LWD,
- identify and implement actions necessary to address fine sediment concerns, and
- identify and correct fecal coliform sources.

Green Cove Creek 13.0133

Fish Passage Barriers - Culverts at four road crossings have been assessed for fish passage (Fish Passage Barrier Database, WDFW SSHEAR 1999), with the only fish passage barrier identified at the 36th Ave. crossing (Table 9). This culvert has recently been repaired by WDFW. Alexander (1998) identified riparian concerns for Green Cove Creek.

Data included in the Green Cove Habitat Database (Cramer, Thurston County) indicate that a lack of pool habitat and lack of LWD are also likely limiting factors in Green Cove Creek. Of the 1,422 meters of habitat sampled from Kaiser Rd. to the estuary, only 8.9% of the channel length, and 8.2% of the channel area was pool habitat. This is significantly less than the threshold for functional pool habitat identified in the Wild Salmonid Policy, which is 55% pools for streams <15 meters wide. LWD also appears to be below a functional threshold, with only 67 pieces (31 small, 19 medium, 17 large, 0 rootwads) counted in the 1,422 meter sample area. Information on other habitat factors was not available. The basin plan recommends preservation of 60% of the undisturbed forest vegetation in the basin to protect instream flows. This non-structural approach to stormwater management was estimated to have a higher probability of success than use of structural stormwater approaches taken elsewhere, which have shown limited success to date.

Action Recommendation – The following habitat restoration actions are recommended:
- implement basin plan recommendation to maintain 60% of watershed in undisturbed forest vegetation, and
- protect sensitive areas through purchase, conservation easements, or other non-regulatory or regulatory options,
- restore functional riparian buffers throughout the drainage, and
- develop and implement an interim strategy to supplement key piece LWD in the creek until restored riparian habitat is capable of contributing functional LWD.

Unnamed 13.0135

No information on habitat limiting factors was identified by the TAG for this stream.

Houston Creek 13.0137

The Fish Passage Barrier Database (WDFW SSHEAR 1999) identifies the culverts in the road crossings at 17th Ave. (currently scheduled for repair) and Houston Dr. (recently fixed) as being barriers to fish passage (Table 9).

Action Recommendation – The following habitat restoration actions are recommended:
- prioritize and correct identified fish passage barriers.

McLane Creek 13.0138, Swift Creek 13.0139, Perkins Creek 13.0140, Cedar Flats Creek 13.0141, Unnamed 13.0142, and Beatty Creek 13.0143

The Fish Passage Barrier Database (WDFW SSHEAR 1999) identifies the culverts in the road crossings over Swift Creek at Munson Rd, Cedar Flats Rd., and 2-4 private crossings as barriers to fish migration (Table 9). [Note: barriers 2088 and 410 have low priority index numbers and Thurston County Roads and Transportation Services has declined intent to fix.] It is unclear whether the fish passage barriers identified by the TAG on Perkins and Beatty creeks are included in the Fish Passage Barrier Database (WDFW SSHEAR 1999).

Habitat monitoring conducted by Schuett-Hames et al. (1996) within this watershed has been limited to one reach each on McLane and Swift creeks, and identifies the following habitat limiting factors:

- the total count of LWD pieces in each segment rated as good, the presence of key piece LWD rated as poor,
- pool surface area >50% in both segments (fair), and pool frequency of 2.71 and 2.39 bankfull widths per pool (fair), respectively,
- mean residual pool depths were 0.39 and 0.41 meters, respectively,
- substrate sampling using McNeil samplers found fine sediment levels of 16.8% and 14.4% (both fair), respectively, and
- canopy closure was below that necessary to maintain stream temperature in both stream segments.

Action Recommendations: The following salmonid habitat restoration actions are recommended:

- restore functional riparian zones (with emphasis on conifer) to address temperature and LWD concerns,
- develop and implement an interim strategy to supplement key piece LWD in the creek until restored riparian habitat is capable of contributing functional LWD, and
- identify and implement actions necessary to address fine sediment concerns.

DATA GAPS

Physical habitat assessment data in WRIA 13 is currently limited to the mainstem Deschutes River (mouth to RM 41), short reaches in each of Percival, Black Lake Ditch, Schneider, McLane and Swift creeks, and Green Cove Creek (limited data). The ability to determine what factors are limiting salmonid production, and to prioritize those impacts within and between drainages, is limited by the current lack of specific habitat assessment data. The following list recommends additional habitat data that would be beneficial in making reasoned restoration recommendations for WRIA 13. Where possible, it is recommended that Timber/Fish/Wildlife (TFW) Protocols be utilized for habitat assessment and monitoring efforts.

Stock Status

Investigate to what extent chinook in Woodland, Percival, and McLane creek watersheds may be self-sustaining populations. Determine whether Budd Inlet chum are a separate chum stock from Eld Inlet and Henderson Inlet chum stocks, or whether they should be incorporated with one of these neighboring stocks.

Fish Passage

A comprehensive inventory of culverts on State highways and County roads has been completed for WRIA 13. Privately owned culverts upstream of identified fish passage barriers on State and County roads have also likely been inventoried. There is, however, no currently available comprehensive inventory of culverts on private property, ranging from small parcels to large corporate forest or agricultural ownerships. Although many of the privately owned culverts may be in the upper headwaters of streams, they may impair or preclude access to significant cumulative habitat. It is recommended that the existing inventory be expanded to include an assessment of culverts on private lands.

Floodplains

There is good quality habitat monitoring data regarding floodplain connectivity, presence of LWD, presence of pools, bank stability, and off-channel habitat for the mainstem Deschutes River and individual reaches of Percival, Black Lake Ditch, Schneider, McLane and Swift Creeks. Data on presence of pools and LWD are available for lower Green Cove Creek. These data are not generally available for other streams or reaches in WRIA 13. It is recommended that a comprehensive habitat monitoring strategy be developed for WRIA 13, with particular attention to those streams for which information is not currently available. The strategy could be based on representative subsample reaches or comprehensive evaluation of entire drainages.

Substrate

The primary concerns regarding substrate are the stability of the substrate and the level of fine sediment (<0.85 mm) in the substrate. No data were found regarding the stability of substrate in the streams in WRIA 13. Data on the level of fine sediment is currently limited to specific reaches in the mainstem Deschutes, McLane, and Swift creeks. It is recommended that a comprehensive habitat monitoring strategy be developed for WRIA 13, with particular attention to those streams for which information is not currently available. The strategy could be based on representative subsample reaches or comprehensive evaluation of entire drainages.

Riparian

The lack of functional riparian zones was identified as a concern for most streams in WRIA 13. However, little specific information was available to determine the extent of impact associated with riparian condition. The types of vegetation in the riparian area on both the right and left banks of the mainstem Deschutes River are identified, but the width of the riparian buffer is only available for approximately half of the sample reaches, and age/size of vegetation is also not indicated. Some additional qualitative riparian information is available for other streams, although some of the data are dated. It is recommended that a comprehensive assessment of riparian condition be conducted for WRIA 13. The most effective means to accomplish this assessment in a timely manner may be to use available remote sensing data. This data could then help guide riparian restoration strategies. The assessment should be repeated on a periodic basis (every 5-10 years) to update condition and trends.

Water Quality

The primary data encountered related to water quality in WRIA 13 were fecal coliform counts. While there is no direct linkage between fecal coliform and salmonid survival, the data can be used as an indicator of other problems in the watershed (animal access, septic failures, bank instability, high nutrient loads, etc.). Streams/reaches with high fecal coliform counts should be assessed for associated physical habitat conditions that may limit salmonid productivity.

It is recommended that a comprehensive monitoring programs be developed to identify:

- those streams or reaches where summer temperature may be limiting salmonid productivity or affecting upstream migration timing,
- those streams or reaches where dissolved oxygen may be affecting survival or migration,
- the effects of toxics in the estuary on juvenile salmon survival.

These monitoring data will assist in identifying those streams where restoration and protection activities should be prioritized, and would also serve as a comparative baseline to monitor improvement over time as watershed restoration occurs.

Effects of stormwater runoff may be both acute and chronic. Most stormwater runoff monitoring has been associated with runoff magnitude. In addition, monitoring of acute stormwater effects should be conducted. This is particularly important for early fall freshet freshets (early fall rain events that are sufficient to result in overland runoff and outflow from stormwater detention facilities) runoff from roads or parking lots, where high concentrations of gas and oils may build up in the collection basins prior to the initial fall storms.

Water Quantity

One of the key limiting factors for many of the streams in the urbanizing portions of WRIA 13 is the alteration of the natural hydrologic regime. Alteration of hydrologic regime has been directly related to the amount of effective impervious surface in the area, particularly where effective impervious surface exceeds 5-10 percent (Wild Salmonid Policy). The County should reevaluate the recommendations in current watershed plans to ensure that stormwater recommendations are implemented in a manner that provides the necessary protection for salmonids. It is also recommended that comprehensive strategies be developed to contain effective impervious surface to <5-10 percent in developing basins.

There are data that identify that minimum instream flows in the Deschutes River are not currently being met. It is recommended that the HB 2514 process identify whether current instream flow requirements for the Deschutes River are adequate, and identify options to ensure that minimum flows are achieved. Low flow concerns have also been identified for other creeks (Woodland Creek) that may warrant consideration by the HB 2514 process to determine what options are available to maintain/restore low flows.

Lakes

Water quality (temperature, dissolved oxygen) in several of the lakes in WRIA 13 (Capitol Lake, Percival Cove, etc.) and outlet flow from Black Lake through Black Lake Ditch have been identified as a concern. There is little information on the effects on growth and survival of juvenile salmonids and effects to upstream migration of adult salmonids. It is recommended that these effects be further evaluated.

Estuarine

There are significant data to indicate a linkage between shoreline bulkheading and the likely modification or loss of fine grained shallow nearshore substrate. These areas provide important nearshore habitat for prey species and support of juvenile salmonids as they migrate to salt water. Changes in the structure of this substrate may also adversely impact benthic production and production of baitfish (surf smelt and sandlance). It is recommended that a program be established to monitor the nearshore substrate in both bulkheaded and natural shoreline areas. This monitoring should look at particle size and makeup as well as benthic community composition in the sample areas.

Additional Budd Inlet concerns that warrant further investigation include:

- studies to determine the effects of log rafting (significant benthic effects from log rafting documented in Port Angeles harbor (SAIC 1999), and
- investigation of the mothballed fleet site, where high concentrations of copper, lead, and zinc have been identified in sediments (in Budd Inlet/Deschutes R. Watershed Action Plan 1995).

Habitat Protection

A comprehensive strategy is needed to identify, prioritize, and protect (acquisition or easements) key salmonid habitat areas. Of particular importance are off-channel habitats, beaver dam complexes, and wetlands that have open water connections to streams or that regulate the surface water runoff to stream channels. The off-channel habitat areas identified by the Squaxin Island tribe on the Deschutes River (Appendix 2) should be field verified, assessed for quality and quantity, and prioritized for protection based on potential benefit to fish life. These and other key habitat areas should be incorporated into a process for nomination and prioritization of key habitat administered by the lead entity.

WRIA 13 ANNOTATED BIBLIOGRAPHY

Advanced Engineering Consultants. 1979. Woodland Creek Drainage Study for Lacey, Washington and Olympia, Washington. Cities of Lacey and Olympia, Washington.

Advanced Engineering Consultants. 1979. Woodland Creek Pollution Control/Reduction Study for Lacey, Washington. City of Lacey, Washington.

Aitkin, J.K.. 1998. The Importance of Estuarine Habitats to Anadromous Salmonids on the Pacific Northwest: A Literature Review. U.S. Fish and Wildlife Service, Western Washington Office, Lacey, WA.

This report reviews the literature, 1979 to present, on anadromous salmonid utilization of estuaries in the Pacific Northwest.

Alexander, B. 1998. Green Cove Creek Comprehensive Drainage Basin Plan. Thurston County and City of Olympia, Washington.

Segments of Green Cove Creek maintain relatively good coho and chum spawning and rearing habitat; for an urbanizing watershed, its future potential is significant. Recommendation 8.6 suggests implementation of mechanisms that will retain 60% of the undisturbed forest vegetation throughout the basin to protect instream flows. Recommendation 8.2 suggests purchasing development rights (conservation easements) and sensitive areas to protect the basin. Specific salmonid issues identified were:

A. *Coho Rearing Issues: LWD & increased peak flows;*
B. *Coho Spawning Issues: LWD, fine sediments, riparian vegetation;*
C. *Chum Spawning Issues: gravel recruitment.*

Aura Nova Consultants, Brown and Caldwell Inc., Evans-Hamilton Inc., J.E. Edinger and Associates, Department of Ecology, and A. Devol. 1998. Budd Inlet Scientific Study. LOTT, Olympia.

This report documents a large study of Budd Inlet water quality. It concludes that fecal coliform in Budd Inlet is primarily from the Deschutes River and Moxlie Creek. Inner Budd Inlet experiences plankton blooms in the summer that lower dissolved oxygen.

Barreca, J. 1998. Needs Assessment for the Eastern Olympic Water Quality Management Area. Department of Ecology, Lacey.

Stormwater is a major issue in WRIA 13, along with failing on-site septic systems and agricultural practices that lead to water quality violations. Increases in peak flows and decreases in base flows are a primary adverse impact on salmonid habitat. Shallow aquifers and local rivers and streams are in hydraulic continuity. Minimum instream flows in the Deschutes are not met.

Benson, B., E. Gower, L. Cowan, G. Johnson, and J. Lenzi. 1997. Thurston County Barrier Culvert Inventory. Department of Fish and Wildlife, Olympia.

This report evaluated 668 culverts throughout Thurston County; 346 of these culverts were in fish bearing streams. Sixty-one were identified as potential fish passage barriers. Thirty-nine of these culverts warranted repair for benefit to fish. Physical habitat surveys were completed for these culverts and priority index values assigned. Mottman Road, Fairview Road, Chapparal Drive, Sapp Road, and Gull Harbor Road had priority indexes above 30.

Benson, Brian. WDFW Biologist. Personal Communication.

Provided the WDFW Fish Barrier Database and personal culvert survey observations with culvert status on Indian and Moxlie creeks. Olympia, WA.

Bilby, R.E. and J.W. Ward. 1989. Changes in characteristics and function of woody debris with increasing size of streams in Western Washington. Transactions of the American Fisheries Society 118:368-78.

This report evaluated the role of large woody debris in second to fifth order streams in western Washington. The report evaluated the frequency, orientation, and size of woody debris, and its role in creating pools, retaining sediment, and retaining organic debris.

Butkus, S. and D. Lynch. 1996. Washington State Water Quality Assessment: section 305(b) report. Department of Ecology, Lacey.

This report lists streams that do not meet Clean Water Act water quality standards. The streams include the Deschutes (FC, fine sediment, instream flow, LWD, pH, temperature), Capitol Lake (FC, P), Ayer or Elwanger Creek (DO, FC, pH), Riechel Creek (FC), Huckleberry Creek (FC, temperature), McLane Creek (pH), Woodard Creek (DO, FC, pH), and Woodland Creek (DO, FC, instream flow, temperature).

Calambokidas, J., G. Steiger, H. Everson, and S. Jefferies. 1991. Census and Distribution of Harbor Seals at Woodard Bay and Recommendations for Protection. Cascadia Research, Olympia.

Up to 500 harbor seals use the log dump at the Woodard Bay Natural Resource Conservation to rest and give birth. The report recommends further research into harbor seal food habits to determine their impact on local fisheries.

Caldwell & Associates Environmental Consulting. 1996. Fish Habitat Investigation: Indian Creek. City of Olympia, Washington.

Indian Creek is strongly effected by urbanization, but some potential salmonid spawning habitat exists between Boulevard Road and Eastside Street. The segment lacks LWD, although riparian vegetation shades much of the segment. Poor water quality is at least as important a contributor to population limits.

Caldwell & Associates Environmental Consulting. 1997. Percival Creek Basin (*Olympia & Tumwater, Washington*): current and future conditions. City of Olympia, Washington.

A healthy riparian corridor is necessary for recruitment of LWD and maintenance of shade to protect salmonid habitat in Percival Creek. This report recommends active management and protection of riparian areas to prevent future development.

Canning, D.J. and H. Shipman. 1995. Coastal Erosion Management Studies in Puget Sound Washington: Executive Summary. Washington Dept. of Ecology Report 94-74. Olympia, WA.

This report is one in a series of reports commissioned or completed by the Shorelands and Coastal Zone Management Program of the Washington Department of Ecology. The report provides a summary of shoreline armoring studies (particularly in Thurston County), general coastal zone erosion management techniques, and the impacts of erosion management.

City of Lacey. 1995. Woodland Creek/Lake Lois Enhancement Project. Lacey, Washington.

This report presents design suggestions for improving the wetland and stream habitat around Lake Lois in Lacey.

City of Olympia. 1995a. East Bay Habit Enhancement Plan. Olympia, Washington.

This report presents design suggestions for improving the estuary and shoreline habitat in East Bay, at the outflow of Moxlie Creek.

City of Olympia. 1995b. Impervious Surface Reduction Study: final report. Olympia, Washington.

When impervious surface coverage reaches 10-15% of total land area, stream quality cannot be maintained. Percival, Woodard/Woodland, and Chambers drainage basins total 37,000 acres. Late 1980's impervious surface was estimated at 14% with build-out bringing it to 29%. Reduction of vehicle-oriented pavement presents the greatest opportunity for reduction of impervious surface.

City of Olympia. 1997. Grass Lake Refuge Final Master Plan. Olympia, Washington.

Additional field surveys are needed to understand fish stock status and habitat value of the Grass Lake wetland complex. A major function of the system is to mitigate peak flows in Green Cove Creek.

City of Olympia, City of Tumwater, Thurston County, and Department of Ecology. 1993. Percival Creek Comprehensive Drainage Basin Plan. Olympia, Washington.

Percival Creek has some good quality salmon habitat, but increased peak flows from urban development threaten its status. The plan recommends stormwater improvements, revegetation projects to address streambank erosion, land acquisition/conservation easements, and fish barrier removal (note: only one partial block remains). Specific salmonid issues identified were:

A. <u>Fish Issues</u>: peak flow and fish passage.

City of Olympia, Thurston County, and Department of Ecology. 1992. Indian/Moxlie Creek Comprehensive Drainage Basin Plan. Olympia, Washington.

Urban development has changed the hydrology and complexity of the creek system impairing salmonid productivity. The plan recommends stormwater improvements, channel reconstruction, and fish passage barrier removal. Specific salmonid issues identified were:

A. Fish Issues: peak flow and fish passage.

Collins, B. 1994. A Study of Rates and Factors Influencing Channel Erosion along the Deschutes River, Washington with Application to Watershed Management Planning. Squaxin Island Tribe Natural Resources Department, Shelton.

Channel erosion along the Deschutes River is primarily the result of the geology and topography of the young, glacial valley. Land uses have probably not significantly accelerated the rate and distribution of soil erosion. Collins concluded that there is no compelling evidence of a systematic increase in bank erosion after study of 50 years of photographic records. With no clear culprit, nothing short of a widespread program of bank protection will stop the soil erosion. However, such a program will be prohibitively expensive and change the river and its ecology. A better strategy might be to restore mature, riparian forests to agricultural lands along the river.

CH2M Hill. 1978. Water Quality in Capitol Lake, Olympia, Washington. Department of Ecology and General Administration, Olympia.

Capitol Lake experiences algal, turbidity, fecal coliform, and sediment deposition problems. Nonpoint sources of pollution originating along the Deschutes River and with waterfowl on the lake are the primary problem. The excessive nutrient loading rates need to be controlled.

Cramer, D. 1997. Deschutes River Reach Scale Analysis and Habitat Survey. Thurston County, Washington.

The Deschutes River between Tumwater Falls and Deschutes Falls was segmented into 343 reaches and a habitat survey completed. Bank erosion is active even in reaches where near pristine conditions exist. Slowing channel erosion is not practical; the river is intent on reclaiming the glacial terraces in the valley and widening its floodplain. Dredging Capitol Lake is an easier approach to solve the sediment problem than addressing upstream soil erosion. Fish habitat is good to poor. The Deschutes lacks key pieces of LWD and off-channel rearing areas.

Davis, S. and R. Coots. 1989. Woodland and Woodard Creek Basin Stormwater Quality Survey. Thurston County, City of Lacey, and City of Olympia, Washington.

This study characterized stormwater quality. Twenty-nine organic contaminants and seven toxic metals were found in storm drain sediments. The plan recommends a more aggressive stormwater management program to address the pollution problem.

Davis, S., S. Berg, and J. Michaud. 1993. Budd Inlet/Deschutes River Watershed Characterization: part II, water quality study. Thurston County, Washington.

Water quality was characterized in the Budd/Deschutes Watershed from 1990-92. The report identified a number of water quality concerns: contaminated storm drains in the *urban area, leaking sewer lines, illicit sewer connections, nitrates in groundwater around Chambers Creek, fecal coliform in the Deschutes above Vail Road and in Reichel, Spurgeon, and Elwanger Creeks, and elevated total suspended solids in the Deschutes between Sorenson Road and Highway 507.*

Department of Ecology. 1980. Deschutes River Basin In-stream Resources Protection Program Including Proposed Administrative Rules (WRIA 13). Lacey, Washington.

Closes Deschutes River tributaries and the independent drainages of Woodland Creek, including Long Lake, Pattison Lake, Hicks Lake, Woodard Creek, and McLane Creek to further out-of-stream consumptive appropriation. The Deschutes River mainstem is closed from April 15 to October 31; instream flow requirements are in effect from November 1 through April 15.

Deschutes River Riparian Habitat Plan Technical Advisory Committee. 1993. Deschutes Riparian Habitat Rehabilitation Plan. City of Tumwater, Washington.

The plan is an amendment to the City of Tumwater Shoreline Master Plan. It describes 23 habitat restoration projects on the Deschutes River from the Henderson Bridge to the Olympia Brewery. Most of the land is owned by the city. The projects are to be implemented as part of any shoreline development permit issued for the vicinity or at the discretion of community groups.

Determan, T. 1999. Trends in Fecal Coliform Pollution in Eleven Puget Sound Embayments. Department of Health, Olympia.

This study determined that fecal coliform bacteria are increasing in Henderson Inlet and generally decreasing in Eld Inlet.

Dinacola, R.S. 1979. Relationship of Fish Habitat to Geomorphology and Sediment in the Upper Deschutes Basin. Weyerhaeuser, Centralia.

The authors surveyed 6 km of stream channel in Mitchell, Johnson, Thurston, Little Deschutes, and Lincoln Creeks. Cutbanks covered approximately 70-80% of the stream length where glacial deposits predominate. Where streams flowed through resistant volcanic rock, stream gradients were steeper and the channel confined between steep side slopes. Bank sloughs were common in the volcanic reaches, but fine material did not collect in the channel.

Drost, B., G. Turney, N. Dion, and M. Jones. 1998. Hydrology and Quality of Groundwater in Northern Thurston County, Washington. USGS Water Resources Investigations Report 92-4109 [revised].

This report details the geology and groundwater resources underlying northern Thurston County. Total groundwater use in the GWMA was calculated at 37,000 acre-feet with an additional 17,000 acre-feet of discharge at springs and seeps to maintain baseflows. The quantity of groundwater recharge is was calculated as 310,000 acre-feet.

Eld Inlet Watershed Management Committee. 1989. Eld Inlet Watershed Action Plan. Thurston County, Washington.

This is a plan for the protection of water quality and shellfish in Eld Inlet. Agricultural activities and failing on-site septic systems within the watershed were thought to be the primary sources of nonpoint pollution.

Entranco Inc. 1990. Erosion/Nonpoint Source Pollution Control Plan: Deschutes River/Capitol Lake System. General Administration, Olympia.

This report builds on the Puget Sound Cooperative River Basin Team (1990) study. It recommends best management practice implementation to address soil erosion and nonpoint source pollution.

Entranco Inc. 1998. Capitol Lake Adaptive Management Plan: draft EIS. General Administration, Olympia.

Existing conditions, five action alternatives, and a no-action alternative for management of Capitol Lake are discussed. The estuary option or a combined lake/estuary option offered the most benefit to salmonid habitat.

Fromuth, C. 1993. 1994 Deschutes River Nominated Bioengineering Sites. Thurston Conservation District, Olympia.

Twenty-two sites along the Deschutes River were evaluated for streambank erosion and prioritized for bioengineering design and funding. This project list has been used to make grant application decisions for bioengineering funding by the Thurston Conservation District.

General Administration. 1977. Capitol Lake Restoration and Recreation Plan. State of Washington, Olympia.

The plan recommends selective dredging within Capitol Lake and recreational enhancement of its shoreline.

Hofstad, L. 1990. Eld Inlet and Watershed 1987- 1989: a water quality and remedial action report. Thurston County, Washington.

Eld Inlet water quality is threatened during storm events. Both marine shoreline and watershed streams are effected by the nonpoint pollution. McLaneCreek is the worst, followed by Perry, Green Cove, and Simmons Creeks. Remedial efforts to fix failing septic systems and implement best management practices on farms have improved the situation.

Hansen, C. 1992. Eld, Henderson, and Totten Watershed Plan Implementation Sediment Sampling Report. Thurston County, Washington.

Fecal coliform bacteria levels were high in all sediment samples. Eighteen organic contaminants and twelve toxic metals as well as five pesticides were detected in the sediments. Highest concentrations were found near areas with light commercial land use and urban stormwater discharge.

Harrison, B. and L. Hofstad. 1988. Henderson, Eld and Totten Inlets 1986 -1987 Water Quality Investigation: final report. Thurston County, Washington.

The report identified agricultural waste as the greatest potential source of fecal coliform bacteria in McLane and Woodard Creeks. Stormwater is a concern in Henderson Inlet streams.

Haub, Andy. City of Olympia. Personal Communication.

Provided specific habitat information for streams within the City of Olympia.

Hofstad, L. 1993. Watershed Implementation: Eld, Henderson, and Totten-Little Skookum 1990-92. Thurston County, Washington.

This report documents early implementation of the Eld and Henderson Watershed Action Plans. Water quality monitoring, sanitary surveys, and ordinance development were the principle activities.

Kettman, J. 1995. Shoreline Armoring Trends in Thurston County, Washington: Property Owner Responses. In Puget Sound Research '95.

Overview of marine shoreline armoring trends in Thurston County from 1977 to 1993.

Koenings, J. 1988 (*revised 1989*). Capitol Lake Restoration: committee report and proposed action plan. Capitol Lake Restoration Committee, Olympia.

This study identifies problems in the Capitol Lake as sediment, fecal coliform bacteria, and high nutrient levels. It recommends 22 actions to correct the problems.

May, C. 1999. Personal Communication – Watershed Habitat Data for Puget Sound Streams. Olympia, WA.

Database of habitat parameters for streams throughout the Puget Sound basin. Of particular relevance to WRIA 13 are data from Percival Creek, Black Lake Ditch, and Schneider Creek.

Moore, A. and D. Anderson. 1978. Deschutes River Suspended Sediment Study. Department of Ecology Project Report DOE-PR-7.

This study found that Mitchell Creek, the largest tributary in the upper basin, transported more sediment than any other headwater tributary. It contributed 19% of the total sediment load of the river above the 1000 Road. The authors considered Mitchell Creek to be a stable area and sediment levels representative of background levels. They concluded that forest practices did not have a large impact on suspended sediment in the river.

Morrison, S. and J. Kettman, and D. Haug. 1993. Inventory and Characterization of Shoreline Armoring, Thurston County, Washington, 1977-1993. Coastal Erosion Studies Volume 3. Department of Ecology, Lacey.

Shoreline armoring increased from 14% of total shoreline length in 1977 to 29% in 1993. The majority of shoreline armoring is concrete bulkheads.

Nelson, M. 1974. Sediment Transport by Streams in the Deschutes and Nisqually River Basins, Washington, November 1971-June 1973. USGS Open File Report.

This study monitored sediment concentrations in the Deschutes River and tributaries. Mitchell Creek had extremely high sediment levels; considerably higher than any other point in the river system. Nelson concluded that logging the headwaters was responsible for most of the sediment deposited in Capitol Lake.

Northwest Indian Fisheries Commission. 1999. Salmon and Steelhead Habitat Inventory Assessment Project (SSHIAP). Lacey, Washington.

SSHIAP is a database of riparian and instream habitat information maintained by the NWIFC.

Orsborn, J.F., J.E. Ongerth, G.C. Bailey, S.K. Bhagat, W.H. Funk, C.C. Lomax, and W.C. Mih. 1975. Hydraulic and water quality research studies and analysis of Capitol Lake sediment and restoration problems, Olympia, Washington. General Administration Project Report 7374/9, 12-1310.

This study proposes a plan for dredging Capitol Lake based on hydraulic and sediment studies of the basin.

Pacific Groundwater Group. 1995. Initial Watershed Assessment/Water Resources Inventory Area 13/Deschutes River Watershed. Department of Ecology, Lacey.

After reviewing readily available information, water right allocations in the Deschutes WRIA totals 59,270 acre-feet/year. About half that amount is thought to be actively used. Shallow aquifers are directly connected to adjacent streams. Most water rights are groundwater withdrawals; some are surface water withdrawals. Commercial and industrial activities use 16% of the groundwater allocation and irrigation uses 8%; the remainder is for municipal and domestic use. About 90% of the surface water allocation is used for irrigation. Minimum instream flow requirements are in effect for the Deschutes between November 1st and April 14th. The flow of the Deschutes regularly falls below target levels. Therefore, instream flow needs for chinook should be considered in determining future water withdrawals.

Puget Sound Cooperative River Basin Team. 1990. Deschutes/Budd Inlet Watershed, Thurston County, Washington. USDA/SCS, USDA/FS, and WDF, Olympia.

Nonpoint sources of pollution impact water quality. Sediment deposited in Capitol Lake is a major problem. Forest practices are a significant contributor. Animal waste is a major source of fecal coliform contamination in the water.

Puget Sound Water Quality Action Team. 1997. 1997-99 Puget Sound Water Quality Work Plan. State of Washington, Olympia.

The report identifies nonpoint pollution and shellfish concerns in Thurston County and actions to address the situation.

Puget Sound Water Quality Action Team. 1997. Local Priorities for the 1999-2001 Puget Sound Water Quality Work Plan. State of Washington, Olympia.

The report identifies funding, stormwater, failing septic systems, and program coordination as areas to address in the next workplan.

Reid, L.M. 1981. Sediment production from gravel-surfaced forest roads, Clearwater Basin, Washington. University of Washington, Seattle.

Soil erosion on the surface of gravel logging roads is a significant source of sediment entering streams and rivers in the PNW. Road segments used by 16 trucks/day contribute 1000 times as much sediment as abandoned roads. Paving heavily used roads dramatically cuts the quantity of sediment reaching streams. While landslides potentially contribute more total sediment, fine sediment contribution is nearly identical.

Robel, Joe. Environmental Permit Specialist. Personal Communication. Olympia, WA.

Indicated experience with some rock constructed marine bulkheads resulting in an increase in the amount of nearshore fine sediment.

Schreffler, D.K., R. Thom, and K.B. Macdonald. 1995. Shoreline Armoring Effects on biological Resources and Coastal Ecology in Puget Sound. In Puget Sound Research '95 Proceedings. Puget Sound Water Quality Authority, Lacey, WA.

The paper provides an overview of the effects of shoreline armoring on habitat structure, ecological processes, and selected biological resources of the nearshore zone of Puget Sound. It briefly addresses cumulative ecological effects – potentially the most damaging but least understood effects of shoreline armoring. Concludes that shoreline armoring results in significant alterations of nearshore habitat and ecological processes. Schuett-Hames, D. and H. Flores. 1994. The Squaxin Island Tribe/ Thurston County streambed characterization contract; 1992-93. Squaxin Island Tribe Natural Resources Department, Shelton.

A stream survey of several segments found significant erosion sites on the Deschutes at RM 12.4 and 37.4, a high proportion of fine sediment in spawning gravel, and a lack of canopy cover and LWD leading to elevated stream temperatures and insufficient pool habitat.

Schuett-Hames, D. and H. Flores. 1994. Final Report: The Squaxin Island Tribe/Thurston County Streambed Characterization Contract; 1992-93. Squaxin Island Tribe Natural Resources Department, Shelton.

Habitat and large woody debris surveys in the Deschutes River between river mile 33 and 45.5. Spawning gravel fine sediment samples from 6 segments on the mainstem Deschutes, and from Mitchell, Huckleberry, Johnson, and Thurston creeks.

Schuett-Hames, D. and I. Child. 1996. An Assessment of Stream Temperature, Large Woody Debris Abundance, and Spawning Gravel Fine Sediment Levels in the Main Stem Deschutes River, 1995. Squaxin Island Tribe Natural Resources Department, Shelton.

A stream survey found five, scattered river segments with fine sediments above optimum and functional, key pieces of LWD below optimum. A lack of forest canopy closure over *the river led to elevated stream temperatures. The authors concluded that protection and restoration of the riparian vegetation will improve salmonid habitat.*

Schuett-Hames, D., H. Flores, and I. Child. 1996. An Assessment of Salmonid Habitat and Water Quality for Streams in the Eld, Totten-Little Skookum, and Hammersley Inlet-Oakland Bay Watersheds in Southern Puget Sound, Washington 1993-94. Squaxin Island Tribe Natural Resources Department, Shelton.

A stream survey of two segments of McLane Creek and one segment of Swift Creek found that total LWD is good, but key LWD is poor leading to a lack of pool habitat. Fine sediment is slightly elevated and canopy closure not quite sufficient to maintain stream temperature.

Scientific Applications International Corporation (SAIC). 1999. Port Angeles Harbor Wood Waste Study – Port Angeles, Washington. Prepared for Washington State Department of Ecology, Olympia, WA.

This study evaluates the impacts of wood waste, primarily from log rafting, on the substrate and benthic invertebrate productivity in Port Angeles Harbor. In addition, the report attempts to identify causes and cures for the low level of dissolved oxygen in the harbor.

Seiders, K. and R. Cusimano. 1996. Totten and Eld Inlets Clean Water Projects: 1996 annual report. Department of Ecology 96-342.

This report summarizes the first four years of a ten year project to monitor water quality and pollution controls in Eld Inlet. Most of the pollution controls are best management practices to address agricultural nonpoint pollution. Fecal coliform bacteria levels are highly variable which supports the need for long term monitoring.

Seiders, K. 1999. Totten and Eld Clean Water Projects: 1997 annual report. Department of Ecology 99-316.

This report summarizes the first five years of a ten year project to monitor water quality and pollution controls in Eld Inlet. Voluntary participation in pollution control implementation programs has been variable. This has confounded results and underlined the need for a better understanding of watershed functions.

Seiler, Dave. WDFW Biologist. Personal Communication. Olympia, WA.

Provided data on the spawning escapements of Deschutes coho and chinook.

Squaxin Island Tribe. 1991. Monitoring of the Upper Deschutes Watershed. Shelton, Washington.

This report documents soil erosion and mass wasting in the upper watershed. Several segments of the Deschutes and upper tributaries have streambanks over 50% eroded and there are five episodes of mass wasting over 1000 ft^2*. The relationship of these events to forest practices is not clear.*

Starry, A. 1990. Henderson Inlet Watershed 1987-89: a water quality and remedial action report. Thurston County, Washington.

Water quality in the inlet was found to suffer as a result of rainfall events. Woodland and Woodard Creeks contribute the greatest bacterial loads. One stormwater outfall contributes 15% of the fecal coliform bacteria in Woodland Creek.

Steinbrenner, E.C. and F.E. Gehrke. 1964. Soil Survey of Vail Tree Farm. Weyerhaeuser, Tacoma.

Soils on Weyerhaeuser land developed on glacial silts, clays, sand, and gravel deposits and are highly variable. They range from clay with low permeability to glacial outwash with high permeability.

Sullivan, K., S. Duncan, P. Bisson, J. Heffner, J. Ward, R. Bilby, and J. Nielson. 1987. A Summary Report of the Deschutes River Basin: sediment, temperature, and fish habitat. Weyerhaeuser, Tacoma.

After a literature review and stream surveys, the authors determined that fish rearing habitat has not deteriorated as a result of forest practices. LWD is abundant except in tributaries where stream cleaning followed logging. Pools are abundant except in tributaries with were debris torrents occurred. However, forest management has increased the sediment load in the river mostly from construction and use of logging roads. Over 50% of the sediment and debris delivered to the headwater tributaries via mass failures resulted from the road network. Forest practices have not statistically increased runoff volumes, although water temperature has increased in small streams with timber harvest.

Swotek, J. 1994. Upper Deschutes River Sediment Reduction Project. 1993 -1994. Thurston Conservation District, Olympia.

Three bioengineering projects were evaluated one year after construction and found generally functional. Additional long term monitoring is recommended to understand their fate in the river system. A reduction of 4000 yrs^3 *of sediment to Capitol Lake over a 20 year period is predicted. This will save $40,000 in dredging costs. The projects cost $36,000.*

Taylor, M. 1984. The Henderson and Eld Inlet Water Quality Study. Department of Ecology, Lacey.

Henderson Inlet has a greater bacteria problem than Eld Inlet. Urban stormwater runoff is the primary source. Livestock and pasture management appear to be a secondary source.

Thorsen, G.W. and K.L. Othberg. 1978. Forest Slope Stability Pilot Project: upper Deschutes River, Washington. Department of Ecology and Department of Natural Resources Open File Report 79-16.

This survey identified twelve major sites of eroding streambanks at least 5 meters high. Ten of them are found in an 8 km stretch of the Deschutes from the 1000 Road to Deschutes Falls.

Thurston Conservation District. 1984. Stream Corridor Management Plan for the Deschutes River, Washington. General Administration, Olympia.

The State of Washington asked TCD to develop a plan to economically alleviate sediment deposition in Capitol Lake. TCD identified increased peak flows from logging activity in the upper watershed and urbanization of the Percival Creek basin as a primary cause of the problem. Bank stabilization was determined to be economically feasible for 14/140 erosion sites.

Thurston County. 1989. Henderson Inlet Watershed Action Plan. Olympia, Washington.

This is a plan for the protection of water quality and shellfish in Henderson Inlet. Stormwater, agricultural activities, and failing on-site septic systems within the watershed were thought to be the primary sources of nonpoint pollution.

Thurston County. 1992-1998. Water Resources Monitoring Reports. Olympia, Washington.

These annual reports detail the results of Thurston County's ambient water quality monitoring program.

Thurston County. 1995. Chambers/Ward/Hewitt Comprehensive Drainage Basin Plan. Olympia, Washington.

Chambers Basin contains anadromous fish. The basin has water quality, stormwater runoff, riparian vegetation, and spawning gravel concerns. The plan recommends replanting the riparian corridors and augmenting gravel in Chamber Creek below Rich Road. Specific salmonid issues identified were:

A. <u>Fish Issues</u>: riparian vegetation and spawning gravel.

Thurston County Advance Planning and Historic Preservation. 1995. Budd Inlet-Deschutes River Watershed Action Plan. Olympia, Washington.

The plan reviews flooding and erosion, forest practices, agricultural practices, wastewater management, stormwater management, and the marine environment. It recommends no building in the floodplain and meander belt, and development of several management strategies: a LWD restoration strategy, a riparian corridor management strategy, and a forest road management plan. A watershed analysis in the upper watershed is also necessary to understand changes in sediment transport and hydrology.

Thurston County, City of Lacey, and City of Olympia. 1995. Woodland and Woodard Creek Comprehensive Drainage Basin Plan. Olympia, Washington.

Salmonid habitat is fairly good for an urbanizing stream system. Removal of LWD and streamside vegetation is a significant cause of habitat degradation. Increased stormwater runoff and decreased summer base flows are also a significant concern. The plan recommends stormwater facilities, re-establishment of riparian vegetation, and repair of fish passage barriers. Specific salmonid issues identified were:

A. <u>Fish Issues</u>: peak flow, fish passage, and riparian vegetation.

Thurston Regional Planning Council. 1974. Water Pollution Control and Abatement Plan for the Deschutes River Basin: WRIA 13 in Thurston County. Olympia, Washington.

Thurston Regional Planning Council. 1985. Percival Creek Corridor Volume 1: canyon and middle reaches. Olympia, Washington.

Approximately 80% of the flow feeding Percival Cove originates from the Black Lake Drainage Ditch. There are 29 streambank erosion sites in the canyon and middle reaches and stormwater impact is the most significant threat to salmonids. The plan makes several recommendations related to zoning and the shoreline master plan to protect the creek.

Thurston Regional Planning Council. 1986. Percival Creek Corridor Volume 2: upper reaches. Olympia, Washington.

The upper reach contains a wetland associated with Black Lake that provides a significant fisheries habitat resource.

Thurston Regional Planning Council. 1988. Woodard Bay Natural Resources Conservation Area Preliminary Reconnaissance Report. Olympia, Washington.

This report describes the Henderson Inlet fisheries resource as relatively minor. Only Woodard and Woodland Creeks are thought to sustain anadromous fish; Sleepy Creek does not. Coho returns has been about 400 fish each year; 50 or less chinook return to the system. The populations appear to be stable at very low levels.

Thurston Regional Planning Council. 1991. Thurston Regional Wetland Pilot Project. Olympia, Washington.

Approximately 1780 acres of wetland were identified in a 21 mile^2 area of northern Thurston County.

Thurston Regional Planning Council, 1993. Inventory and Characterization of Shoreline Armoring – Thurston County, Washington.

Documented extent and nature of shoreline armoring present in 1993 along the marine shoreline of Thurston County. Compared extent of shoreline armoring identified from aerial photographs of the shoreline taken in 1977 and 1992, verified with a boat survey in 1993. Identified that amount of shoreline armored increased from 14% of total shoreline (1977) to 29% (1993), a 110% increase. Permits issued indicated that 2/3 of the permits were for repair and replacement, and 1/3 for construction of new armoring.

Thurston Regional Planning Council. 1995. Thurston County Regional Wetland and Stream Corridor Section Maps. Olympia, Washington.

Wetlands are mapped for much of Thurston County.

Thurston Regional Planning Council. 1999. Capitol Lake Adaptive Management Plan. General Administration, Olympia.

The plan does not select a preferred alternative for management of Capitol Lake from the EIS (Entranco 1998). It recommends fixing the fish passage barrier at the Capitol Lake tidegate, further monitoring, and sediment removal from Capitol Lake.

Topping, Pete. WDFW Biologist. Personal Communication. Olympia, WA.

Provided spawner escapement and hatchery/wild composition data for Deschutes River coho.

Toth, S. 1991. A Road Damage Inventory for the Upper Deschutes River Basin. Squaxin Island Tribe Natural Resources Department, Shelton and Weyerhaeuser, Tacoma.

A January 1990 storm event caused extensive damage to the upper watershed. Roads built 16-45 years ago were heavily damaged. The majority of problems occurred because of steep cutslopes and blocked culverts. Older culverts need to be replaced to prevent future damage.

Turner, M. 1993. Budd Inlet/Deschutes River Watershed Characterization: part I, watershed description. Thurston County, Washington.

This report details the watershed planning activities active in the Deschutes Watershed.

URS Engineers. 1982. Engineering and Feasibility Assessment at Capitol Lake, Olympia, Washington. General Administration, Olympia.

The Deschutes River was identified as the primary source of bacteria, nutrients, and sediments in Capitol Lake. An additional water quality concern is the crater that has developed upstream of the tidegate. Low DO marine water from Puget Sound settles there endangering migrating salmonid stocks.

Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes. 1994. Washington State Salmon and Steelhead Stock Inventory. Olympia, Washington.

Lists stock status for chinook in South Sound Tributaries (healthy), chum in Henderson (unknown) and Eld Inlets (healthy), coho in Deep South Sound Tributaries (healthy) and the Deschutes (healthy) and steelhead in the Deschutes (healthy) and Eld Inlets (unknown).

Washington Department of Fish and Wildlife and Western Washington Treaty Indian Tribes. 1997. Policy of Washington Department of Fish and Wildlife and Western Washington Treaty Tribes Concerning Wild Salmonids (The Wild Salmonid Policy). Olympia, WA.

Identifies habitat protection and restoration as essential to wild salmonid protection. Identifies policy statements for each of the main habitat elements, identifies performance measures necessary to meet functional habitat, and action strategies to meet those performance measures.

Washington Department of Fish and Wildlife Salmon and Steelhead Habitat Evaluation and Rehabilitation (SSHEAR). 1999. Fish Passage Barrier Database. Olympia, WA.

Separate databases exist for culverts and fishways, which document those sites that have been inventoried and evaluated, those which are fish passage barriers, and for some sites, the estimated amount of habitat that would be gained if the barrier was corrected.

Williams, R., R. Laramie, and J. Ames. 1975. A Catalog of Washington Streams and Salmon Utilization Volume 1: Puget Sound Region. Department of Fish and Wildlife, Olympia.

This report provides a stream-by-stream salmon species inventory and distribution summary, a brief watershed description of WRIA 13, and brief discussion of habitat limiting factors for salmon species in the watershed.

APPENDIX 1

The Relative Role of Habitat in Healthy Populations of Natural Spawning Salmon
(Author: Carol Smith, Ph.D.)

During the last 10,000 years, Washington State salmon populations have evolved in their specific habitats (Miller, 1965). Water chemistry, flow, and the physical stream components unique to each stream have helped shaped the characteristics of each salmon population, which has resulted in a wide variety of distinct salmon stocks for each salmon species throughout the State. Within a given species, stocks are units that do not extensively interbreed because returning adults rely on a stream's unique chemical characteristics to guide them to their natal grounds to spawn. This maintains the separation of stocks during reproduction, thus maintaining the distinctiveness of each stock.

Throughout the salmon's life cycle, the dependence between the stream and a stock continues. Adults spawn in areas near their own origin because survival favors those that do. The timing of juveniles leaving the river and entering the estuary is tied to high natural river flows. It is thought that the faster speed during out-migration reduces predation on the young salmon and perhaps is coincident to favorable feeding conditions in the estuary (Wetherall 1972). These are a few examples that illustrate how a salmon stock and its environment are intertwined throughout the entire life cycle.

Salmon habitat includes the physical, chemical and biological components of the environment that supports salmon. Within freshwater and estuarine environments, these components include water quality, water quantity or flows, stream features, riparian zones, upland conditions, and ecosystem interactions as they pertain to habitat. However, these components closely intertwine. Low flows can alter water quality by increasing temperatures and decreasing oxygen levels. Water quality can impact stream conditions, for example, heavy sediment loads increasing channel instability. The riparian zone interacts with the stream environment, providing nutrients and a food web base, large woody debris for habitat and flow control (stream features), filtering water prior to stream entry (water quality), and providing shade to aid in temperature control.

Salmon habitat includes clean, cool, well-oxygenated water flowing at a normal (natural) rate for all stages of freshwater life. In addition, salmon survival depends upon specific habitat needs for the different life history stages, which include egg incubation, juvenile rearing, migration of juveniles to saltwater, estuary rearing, adult migration to spawning areas, and spawning. These specific needs can vary by species and even by stock.

When adult salmon return to spawn, they not only need adequate flows and water quality, but also unimpeded passage to their natal grounds. They need deep pools for resting with vegetative cover and instream structures such as root wads for shelter from predators. Successful spawning depends on enough gravel of the right size for that particular population, in addition to the constant need of adequate flows and water quality.

After spawning, the eggs need stable gravel that is not choked with sediment. River channel stability is vital at this life history stage for all species of salmonids. Floods have their greatest impact to salmon populations during incubation, and flood impacts are worsened by human activities. In a natural river system, the upland areas are forested, and the trees and their roots store precipitation, which slows the rate of storm water into the stream, lessening the impact of a potential flood. The natural, healthy river is sinuous and contains large pieces of wood contributed by an intact, mature riparian zone. Both slow the speed of water downstream. Natural systems have floodplains that are connected directly to the river at many points, allowing wetlands to store flood water and later discharge this storage back to the river during lower flows. This not only decreases flood impacts, but also recharges fish habitat later when flows are low. In a healthy river, erosion or sediment input is great enough to provide new gravel for spawning and incubation, but does not overwhelm the system, raising the riverbed and increasing channel instability. Lastly, a natural river system allows flood waters to freely flow over unaltered banks rather than constraining the energy within the channel, scouring out salmon eggs. A stable egg incubation environment is essential for all salmon, but is a complex function of nearly all habitat components.

Once the young fry leave their gravel nests, certain species such as chum, pink and some chinook salmon quickly migrate downstream to the estuary. Other species, such as coho, steelhead, bull trout, and chinook, will search for suitable rearing habitat within the side sloughs, side-channels, spring-fed “seep” areas, as well as the outer edges of the stream. These quiet-water side margin and off-channel slough areas are vital for early juvenile habitat. The presence of woody debris and overhead cover aid in food and nutrient inputs as well as provide protection from predators. For most of these species, juveniles use this type of habitat in the spring.

As growth continues, the juveniles (parr) move away from the quiet shallow areas to deeper, faster areas of the stream. These include coho, steelhead, bull trout, and certain chinook. For some of these species, this movement is coincident with the summer low flows. Low flows constrain salmon production. In non-glacial streams, summer flows are maintained by precipitation, connectivity to wetland discharges, and groundwater inputs. Reductions in these inputs will reduce the amount and quality of habitat; hence the number of salmon from these species.

In the fall, juvenile salmon that remain in freshwater begin to move out of the mainstems, and again, off-channel habitat becomes important. During the winter, coho, steelhead, bull trout, and remaining chinook need habitat to sustain their growth and protect them from predators and winter flows. Wetlands, off-channel habitat, undercut banks, rootwads, and pools with overhead cover are important habitat components during this time.

Except for bull trout and resident steelhead, juvenile parr convert to smolts as they migrate downstream towards the estuary. Again, flows are critical, and food and shelter are necessary. The natural flow regime in each river is unique, and has shaped the population’s characteristics through adaptation over the last 10,000 years. Because of the close inter-relationship between a salmon stock and its stream, survival of the stock depends on natural flow patterns, particularly during migration times.

The estuary provides an ideal area for rapid growth, and some salmon species are heavily dependent on estuaries, particularly chinook, chum, and to a lesser extent, pink salmon. Estuaries contain new food sources to support rapid growth, but adequate natural habitat must exist to support the detritus-based food web, such as eelgrass beds, mudflats, and salt marshes. Also, the processes that contribute nutrients and woody debris to these environments must be maintained. Common disruptions to these habitats include dikes, bulkheads, dredging and filling activities, pollution, and alteration of downstream components such as lack of woody debris and sediment transport.

All salmonid species need adequate flow, similar water quality, spawning riffles and pools, a functional riparian zone, and upland conditions that favor stability, but some of these specific needs vary by species, such as preferred spawning areas and gravel. Although some overlap occurs, different salmon species within a river are often staggered in their use of a particular type of habitat. Some are staggered in time, and others are separated by distance.

Chum and pink salmon use the streams the least amount of time. Washington State adult pink salmon typically begin to enter the rivers in August and spawn in September and October, although Dungeness summer pinks enter and spawn a month earlier (WDFW and WWTIT, 1994). During these times, low flows and associated high temperatures and low dissolved oxygen can be problems. Other disrupted habitat components, such as a lack of pools due to sedimentation and lack of canopy from an altered riparian zone or widened river channel, can worsen these flow and water quality problems because there are less refuges for the adults to rest and avoid predators prior to spawning.

The pink salmon fry emerge around March to April, and migrate downstream to the estuary within a month. After a limited rearing time in the estuary, pink salmon migrate to the ocean for a little over a year, until the next spawning cycle. Most pink salmon stocks in Washington are only in the rivers in odd years. The exception is the Snohomish Basin, which supports two pink salmon stocks. One stock spawns in odd years, and the other stock spawns in even years.

Washington Chum salmon have three major run types. Summer chum enter the rivers in August and September, and spawn in September and October. Fall chum adults enter the rivers in late October through November, and spawn in November and December. Winter chum enter from December through January and spawn from January through February. Chum salmon fry emerge from the nests in March and April, and quickly outmigrate to the estuary for rearing. In the estuary, juvenile chum follow prey availability. In Hood Canal, juveniles that arrive in the estuary in February and March migrate rapidly offshore. This migration rate decreases in May and June as levels of zooplankton increase. Later as the food supply dwindles, chum move offshore and switch diets (Simenstad and Salo, 1982).

Both of these species have similar habitat needs such as unimpeded access to spawning habitat, a stable incubation environment, favorable downstream migration conditions (adequate flows in the spring), and because they rely heavily on the estuary for growth, good estuary habitat is essential.

Chinook salmon have three major run types in Washington State. Spring chinook are in their natal rivers throughout the calendar year. They begin river entry as early as February in the Chehalis Basin, but in Puget Sound, entry doesn’t begin until April or May. Spring chinook spawn from July through September and typically spawn in the headwater areas where higher gradient habitat exists. Incubation continues throughout the autumn and winter and generally requires more time for the eggs to develop into fry because of the colder temperatures in the headwater areas. Fry begin to leave the gravel nests in February through early March. After a short rearing period in the shallow side margins and sloughs, all Puget Sound and coastal spring chinook stocks have juveniles that begin to leave the rivers to the estuary over the next several months, lasting until August. Within the Puget Sound stocks, it is not uncommon for other juveniles to remain in the river for another year before leaving as yearlings. The juveniles of spring chinook stocks in the Columbia Basin remain in the river for a full year with no early outmigrating components.

Summer chinook begin river entry as early as June in the Columbia does, but not until August in Puget Sound. They generally spawn in September or October. Fall chinook stocks range in spawn timing from late September through December. All Washington State summer and fall chinook stocks have juveniles that incubate in the gravel until January through early March, and downstream migration to the estuaries occurs over a broad time period (January through August).

The emerging chinook salmon fry inhabit the shallow side margins and side sloughs for about a month or two. Then, some gradually move into the faster areas to rear, and others outmigrate to the estuary. While most summer and fall chinook outmigrate within their first year of life, a few stocks (Snohomish summer chinook, Snohomish fall chinook, upper Columbia summer chinook) have juveniles that remain in the river for an additional year, similar to many spring chinook (Marshall et al, 1995). However, those in the upper Columbia, have scale patterns that suggest that they rear in a reservoir-like environment (mainstem Columbia upstream from a dam) rather than in their natal streams and it is unknown whether this is a result of dam influence or whether it is a natural pattern.

Coho salmon adults typically enter freshwater from September to early December, but have been observed as early as late July and as late as mid-January (WDF et al, 1993). They often mill near the river mouths or in lower river pools until freshets occur, and the onset of spawning is tied to the first significant fall freshet. Spawning usually occurs between November and early February, but is sometimes as early as mid-October and can extend into March. Spawning often occurs in tributaries and sedimentation in these tributaries can be a problem, suffocating eggs. Lack of access to preferred spawning areas is an acute problem for coho, because they favor small tributaries for spawning and impassable culverts are common in these stream reaches.

As chinook salmon fry are exiting the shallow low-velocity rearing areas, coho fry enter the same areas for the same purpose. As they grow, juvenile coho move into faster water and disperse into tributaries and areas that adults cannot access (Neave, 1949). Pool habitat is important not only for returning adults but also for all stages of juvenile development. Preferred pool habitat includes cover and woody debris.

All coho juveniles remain in the river for a full year after leaving the gravel nests, but during the summer after early rearing, low flows can lead to problems such as decreased habitat, increased stranding, decreased dissolved oxygen, increased temperature, and increased predation. Juvenile coho are highly territorial and can occupy the same area for a long period of time (Hoar, 1958). The abundance of coho can be limited by the number of suitable territories available (Larkin, 1977). Streams with more structure (logs, bushes, etc.) support more coho (Scrivener and Andersen, 1982), not only because they provide more territories, but they also provide more food and cover. There is a positive correlation between insect material in their stomachs (their primary diet at this stage) and the extent the stream was overgrown with vegetation (Chapman, 1965). In addition, the leaf litter in the fall contributes to aquatic insect production (Meehan et al., 1977).

In the autumn as the temperatures decrease, juvenile coho move into deeper pools, and hide under logs, tree roots, and undercut banks (Hartman, 1965). The fall freshets redistribute them (Scarlett and Cederholm, 1984), and over-wintering generally occurs in available side channels, spring-fed ponds, and other off-channel sites to avoid winter floods (Peterson, 1980). The lack of side channels and small tributaries may limit coho survival (Cederholm and Scarlett, 1981). As coho juveniles grow into yearlings, they become more predatory on other salmonids.

Coho begin to leave the river a full year after emerging from their gravel nests with the peak outmigration for Puget Sound stocks occurring in early May. Coho use estuaries primarily for interim food while they adjust physiologically to saltwater.

Sockeye salmon have a wide variety of life history patterns, including landlocked populations of kokanee which never enter saltwater. Of the populations that migrate to sea, adult freshwater entry varies from spring for the Quinault stock, summer for Ozette and Columbia River stocks, and summer and fall for Puget Sound stocks. Spawning ranges from September through February, depending on the stock.

After fry emerge from the gravel, most migrate to a lake for rearing, although a few types of fry migrate to the sea. Lake rearing ranges from 1-3 years with most juveniles rearing two years. In the spring after lake rearing is completed, juveniles enter the ocean where more growth occurs prior to adult return for spawning.

Sockeye spawning habitat varies widely. Some populations spawn in rivers (Cedar River) while other populations spawn along the beaches of their natal lake (Ozette), typically in areas of upwelling groundwater. Sockeye also spawn in side channels and spring-fed ponds. The spawning beaches along lakes provide a unique habitat that is often altered by human activities.

Steelhead have the most complex life history patterns of any Pacific salmonid species (Shapovalov and Taft, 1954). In Washington, there are two major run types, winter and summer steelhead. Winter steelhead begin river entry in a mature reproductive state in December and generally spawn from February through May. Summer steelhead enter the river from about May through October with spawning from about February through April. They enter the river in an immature state and require several months to mature (Burgner et al, 1992). Summer steelhead usually spawn farther upstream than winter stocks (Withler, 1966) and dominate inland areas such as the Columbia Basin. However, the coastal streams support more winter steelhead populations.

Juveniles can either migrate to sea (anadromy) or remain in freshwater as rainbow or redband trout. In Washington, those that are anadromous usually spend 1-3 years in freshwater, with the greatest proportion spending two years (Busby et al, 1996). Because of this and their year-round presence in steelhead-bearing streams, steelhead greatly depend on the quality and quantity of freshwater habitat.

Bull trout/Dolly Varden stocks are also very dependent on the freshwater environment. Within a given stock, some adults remain in freshwater their entire lives, while others migrate to the estuary where they rear during the spring and summer. They then return upstream to spawn in late summer. Those that remain in freshwater either stay near their spawning areas as residents, or migrate upstream throughout the winter, spring, and early summer, residing in pools. They return to spawning areas in late summer. In some stocks juveniles migrate downstream in spring, overwinter in the lower river, then enter the estuary and Puget Sound the following late winter to early spring (WDFW, 1998).

In addition to the above-described relationships between various salmon species and their habitats, there are also interactions between the species that have evolved over the last 10,000 years such that the survival of one species might be enhanced or impacted by the presence of another. Pink and chum salmon fry are frequently food items of coho smolts, Dolly Varden char, and steelhead (Hunter, 1959). Chum fry have decreased feeding and growth rates when pink salmon juveniles are abundant (Ivankov and Andreyev, 1971), probably the result of occupying the same habitat at the same time (competition). These are just a few examples.

Most streams in Washington are home to several salmonid species, which together, rely upon freshwater and estuary habitat the entire calendar year. As the habitat and salmon review indicated, there are complex interactions between different habitat components, between salmon and their habitat, and between different species of salmon. For just as habitat dictates salmon types and production, salmon production contributes to habitat and to other species.

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APPENDIX 2

Designation of Deschutes River Floodplain, Active Meander Zone, Floodplain Wetlands, and Off-Channel Habitat Areas

This section includes ortho-photo overlay maps developed and compiled by the Squaxin Island Tribe that indicate the FEMA floodplain, the channel meander zone (recent history), floodplain wetlands, and off-channel habitat areas. There are 18 color maps that cover the river from Tumwater Falls to Deschutes Falls (RM 41).

Deschutes River Off-Channel Habitat Inventory

Map Index

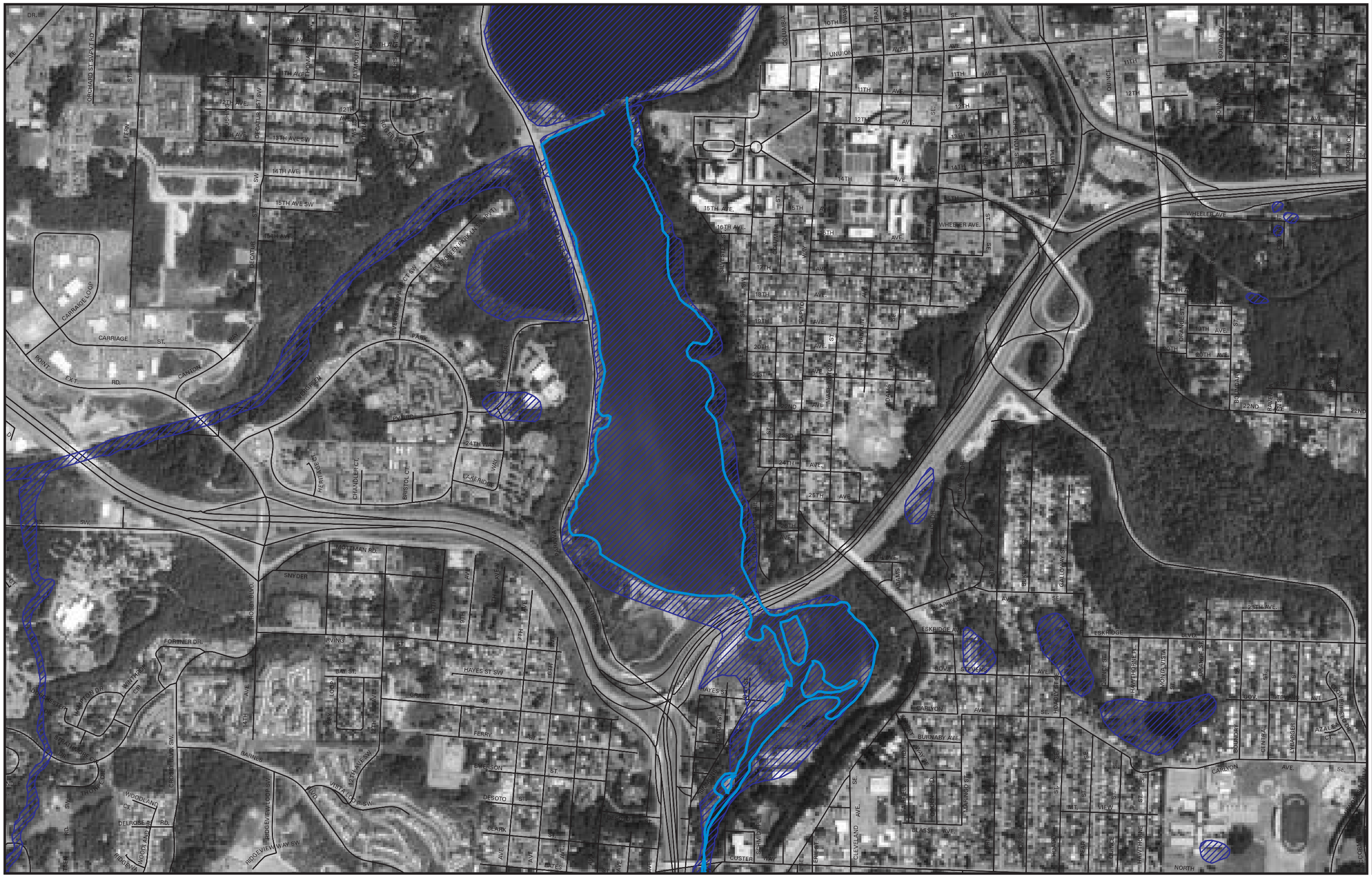
0mi 1mi 2mi

0km 1km 2km 3km 4km

Map Produced By:
Thurston Regional Planning Council
for
Squaxin Island Tribe
Natural Resources

Aerial photos flown in 1996

Deschutes River Off-Channel Habitat Inventory



Legend

- Mainstem and Tributaries
- Meander Zone
- 100-year Floodplain

Habitat Types

- Wetlands
- Overflow Channels

Note: Overflow channels and wetlands were digitized from 1996 one- and three-foot ortho photos and represent a subset of existing features. Selection criteria are listed in: *The Deschutes River Off-Channel Habitat Inventory.*

Map Produced By:

Thurston Regional Planning Council

for

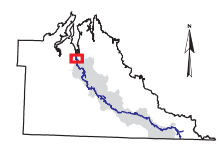
Squaxin Island Tribe
Natural Resources

Aerial photos flown in 1996

0ft 1000ft

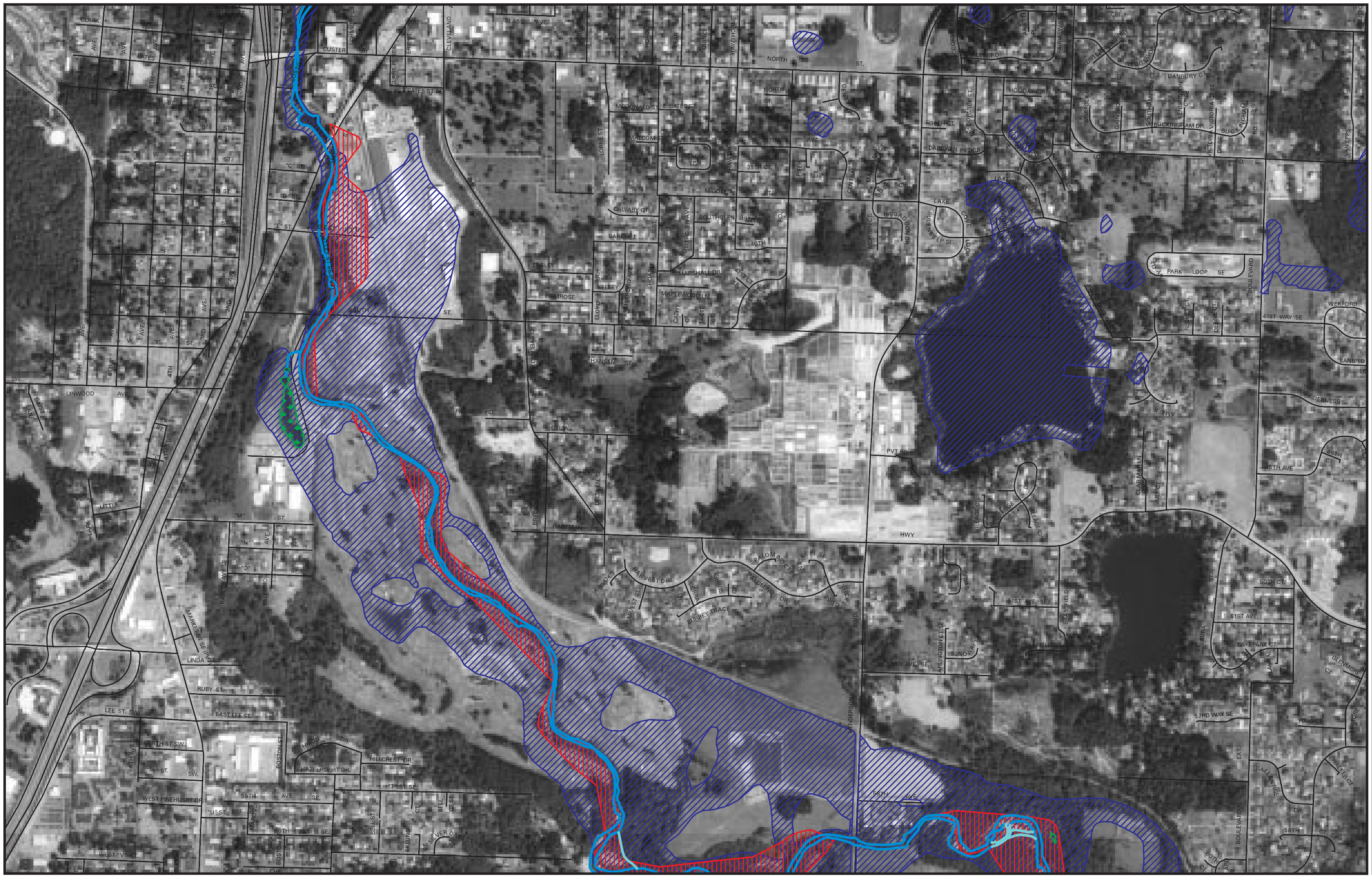
0m 100m 200m 300m

Location Map



Map 1 of 18

Deschutes River Off-Channel Habitat Inventory



Legend

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Map Produced By:

Thurston Regional Planning Council

for

Squaxin Island Tribe
Natural Resources

Aerial photos flown in 1996

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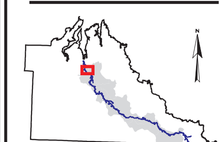
Location Map



Map 2 of 18

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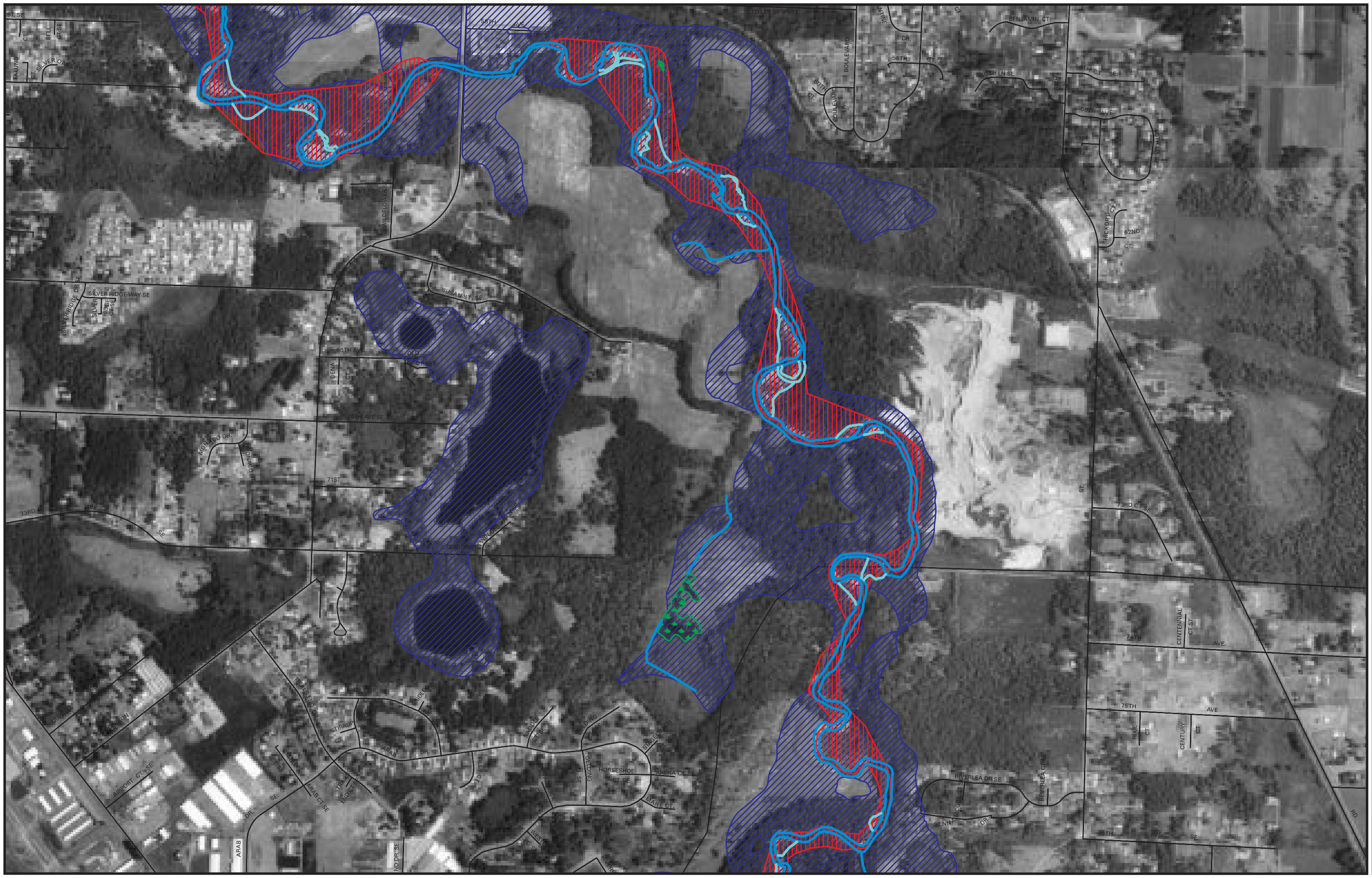
Deschutes River Off-Channel Habitat Inventory



Legend

Mainstem and Tributaries

Meander Zone

100-year Floodplain

Habitat Types

Wetlands

Overflow Channels

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Map Produced By:

Thurston Regional Planning Council

for

Squaxin Island Tribe
Natural Resources

Aerial photos flown in 1996

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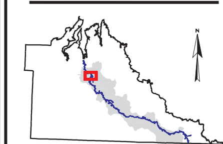
0m 100m 200m 300m

Location Map



Map 3 of 18

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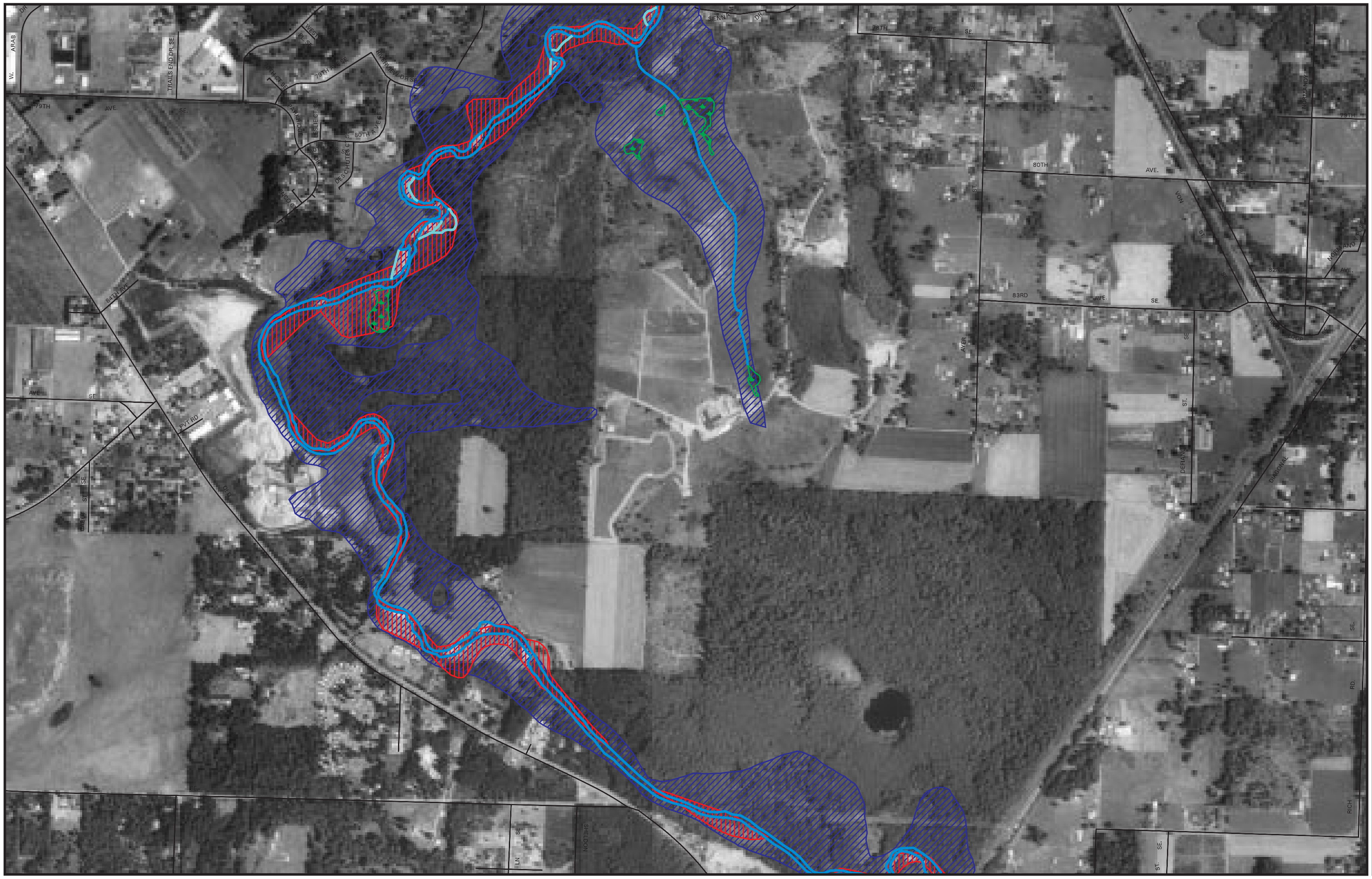
Deschutes River Off-Channel Habitat Inventory



Legend

- Mainstem and Tributaries
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Habitat Types

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Map Produced By:

Thurston Regional Planning Council

for

Squaxin Island Tribe
Natural Resources

Aerial photos flown in 1996

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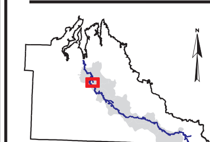
0m 100m 200m 300m

Location Map



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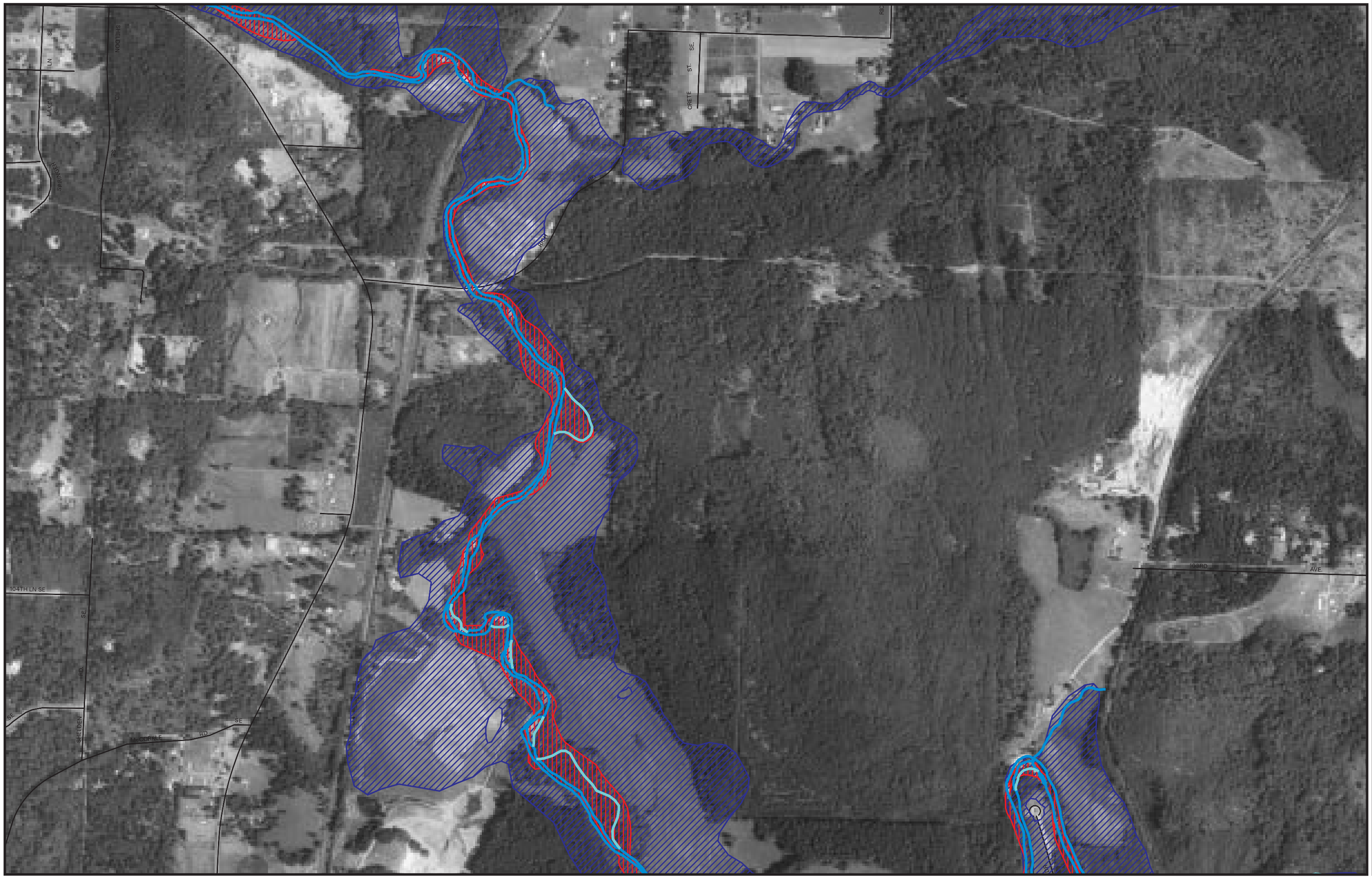
Deschutes River Off-Channel Habitat Inventory



Legend

Mainstem and Tributaries

Meander Zone

100-year Floodplain

Habitat Types

Wetlands

Overflow Channels

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Map Produced By:

Thurston Regional Planning Council

for

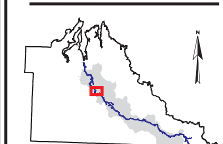
Squaxin Island Tribe
Natural Resources

Aerial photos flown in 1996

0ft 1000ft

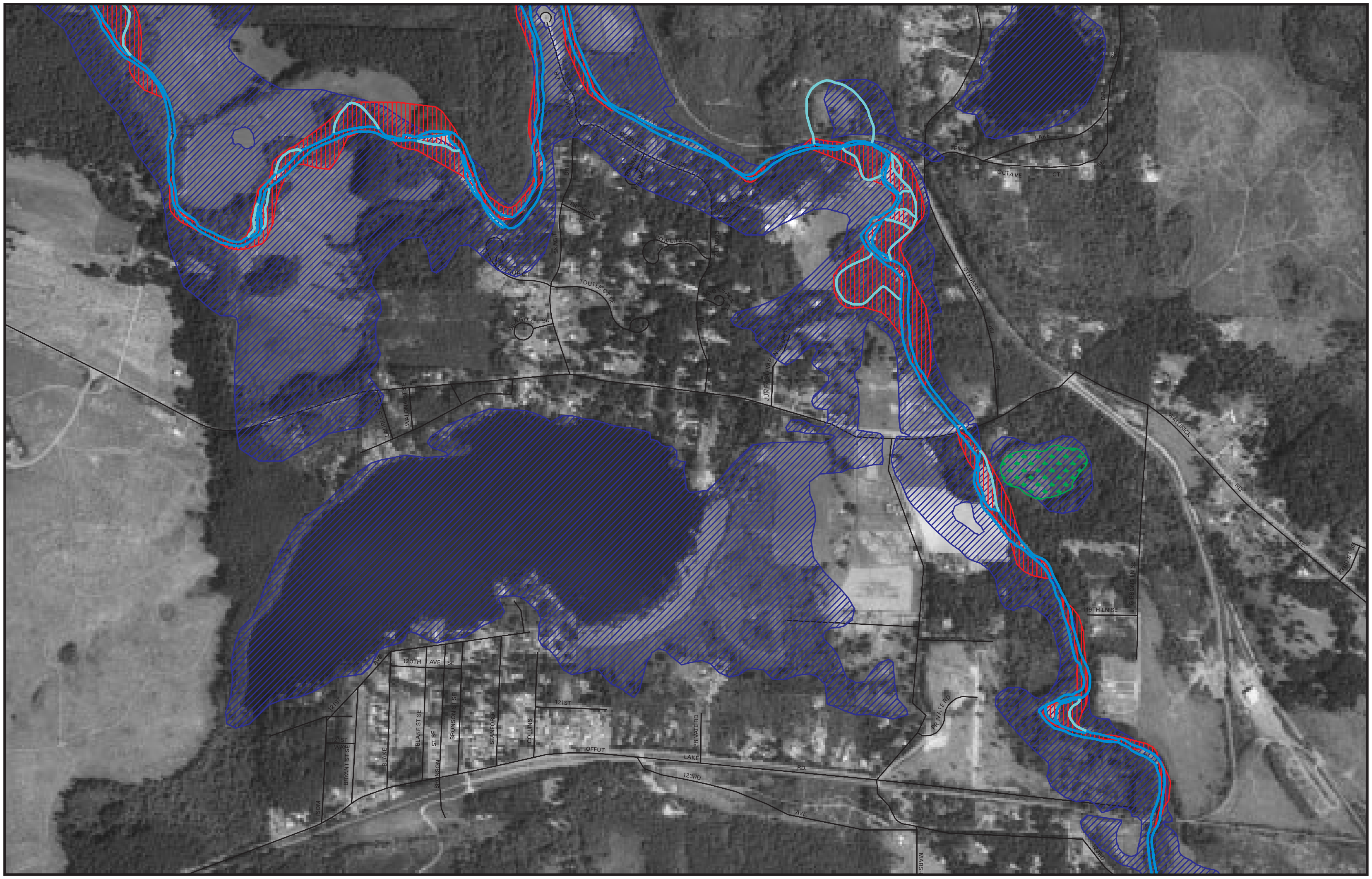
0m 100m 200m 300m

Location Map



Map 5 of 18

Deschutes River Off-Channel Habitat Inventory



Legend

Mainstem and Tributaries

Meander Zone

100-year Floodplain

Habitat Types

Wetlands

Overflow Channels

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Map Produced By:

Thurston Regional Planning Council

for

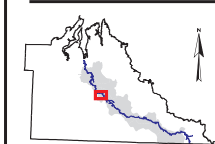
Squaxin Island Tribe Natural Resources

Aerial photos flown in 1996

0ft 1000ft

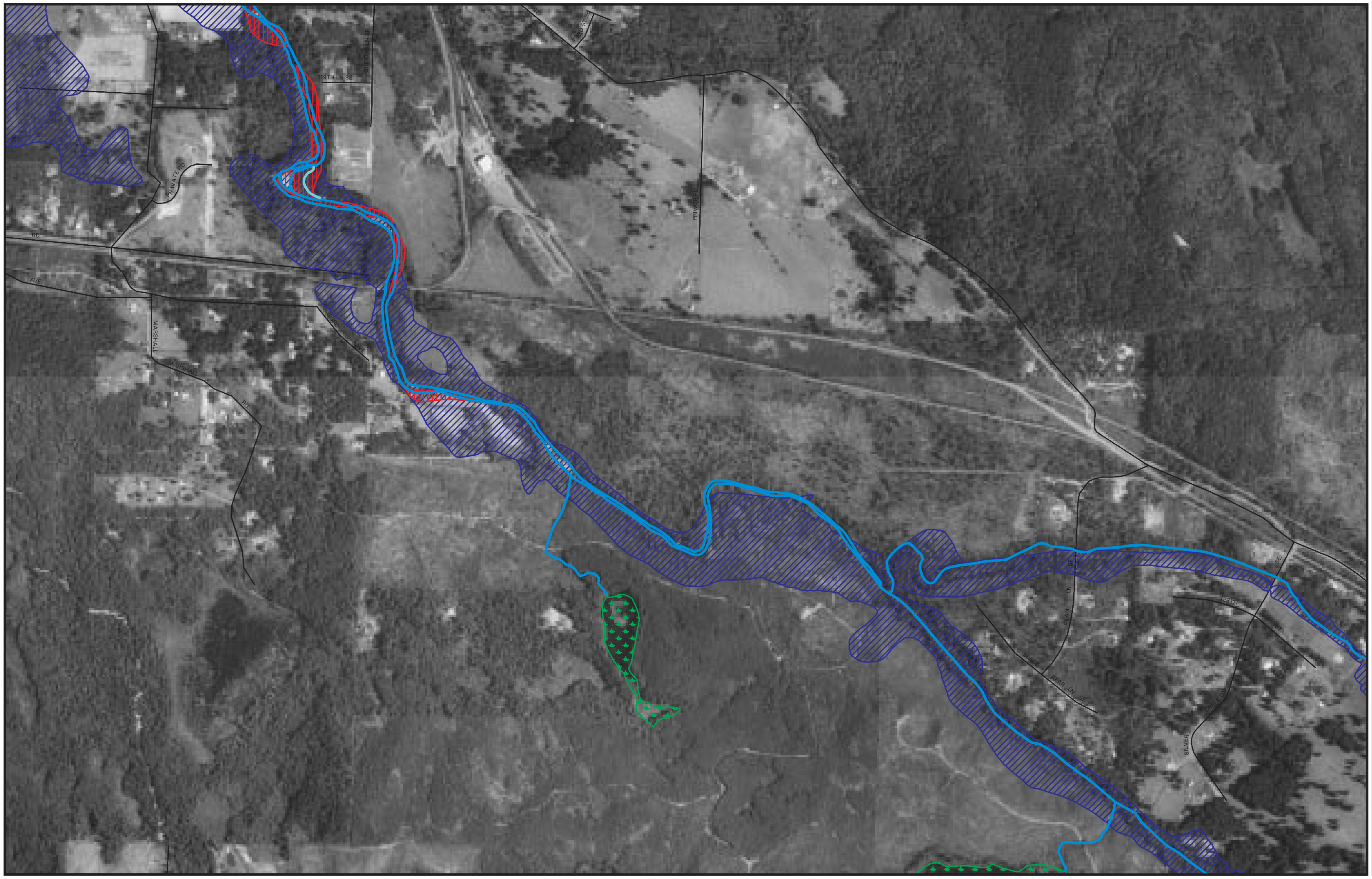
0m 100m 200m 300m

Location Map



Map 6 of 18

Deschutes River Off-Channel Habitat Inventory



Legend

- Mainstem and Tributaries
- Meander Zone
- 100-year Floodplain

Habitat Types

- Wetlands
- Overflow Channels

Note: Overflow channels and wetlands were digitized from 1996 one- and three-foot ortho photos and represent a subset of existing features. Selection criteria are listed in: *The Deschutes River Off-Channel Habitat Inventory.*

Map Produced By:

Thurston Regional Planning Council

for

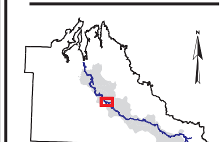
Squaxin Island Tribe
Natural Resources

Aerial photos flown in 1996

0ft 1000ft

0m 100m 200m 300m

Location Map



Map 7 of 18

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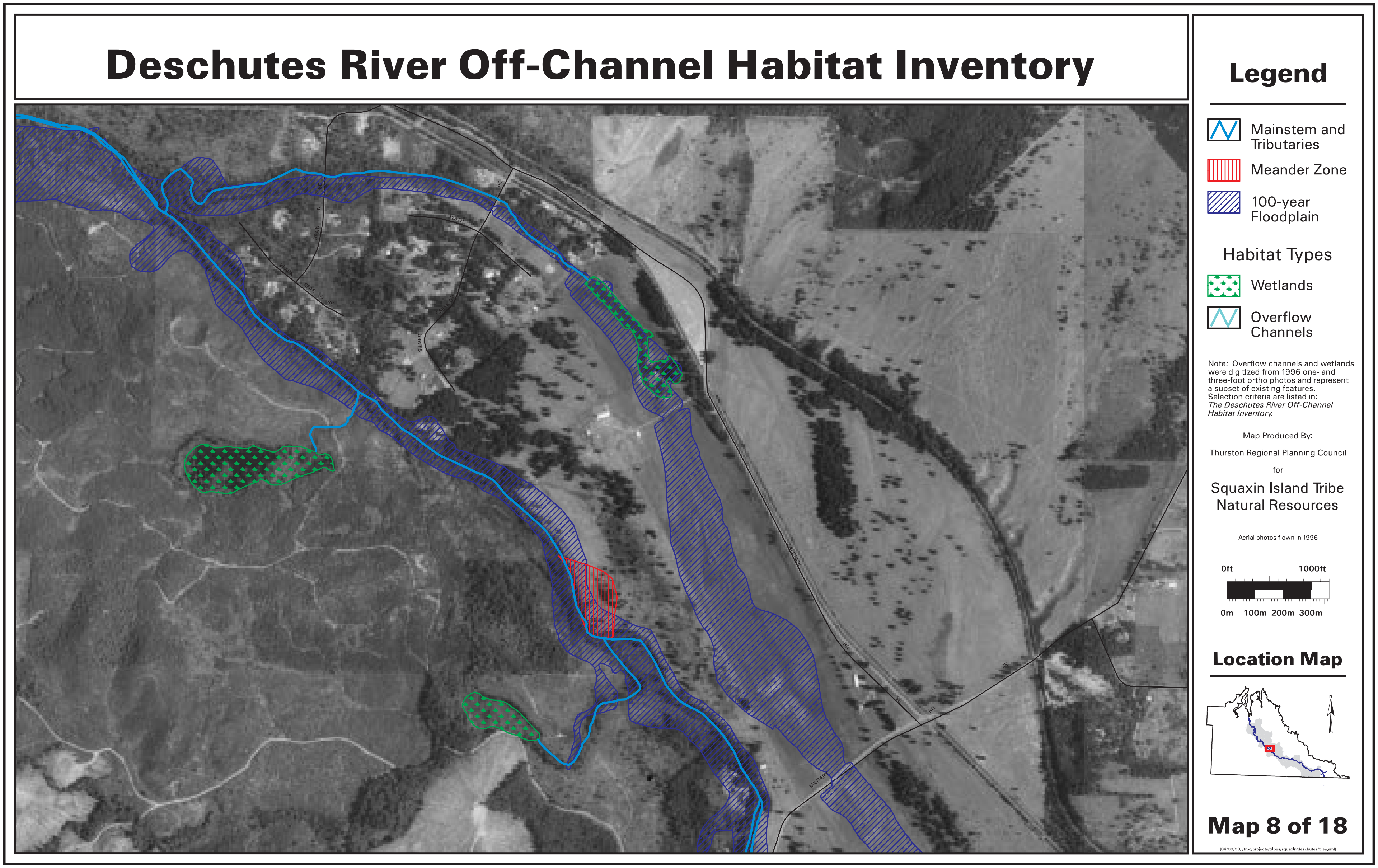
Deschutes River Off-Channel Habitat Inventory
Legend
Mainstem and Tributaries
Meander Zone
100-year Floodplain
Habitat Types
Wetlands
Overflow Channels
Note: Overflow channels and wetlands were digitized from 1996 one- and three-foot ortho photos and represent a subset of existing features. Selection criteria are listed in: The Deschutes River Off-Channel Habitat Inventory.
Map Produced By:
Thurston Regional Planning Council
for
Squaxin Island Tribe Natural Resources
Aerial photos flown in 1996
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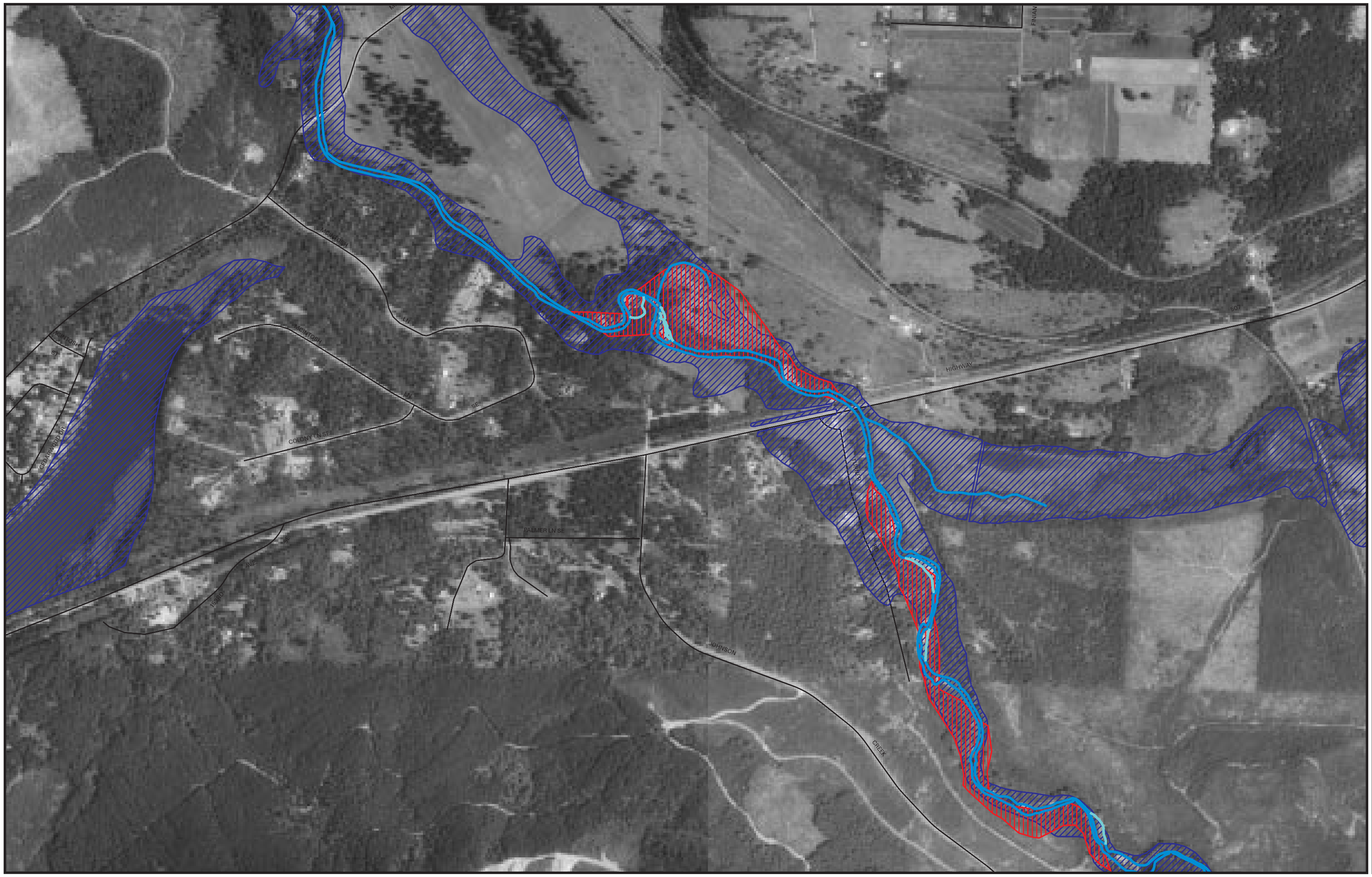
Location Map
Map 8 of 18

Deschutes River Off-Channel Habitat Inventory



Legend

- Mainstem and Tributaries
- Meander Zone
- 100-year Floodplain

Habitat Types

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Map Produced By:

Thurston Regional Planning Council

for

Squaxin Island Tribe
Natural Resources

Aerial photos flown in 1996

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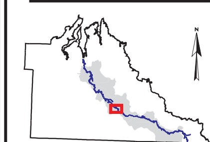
Location Map



Map 9 of 18

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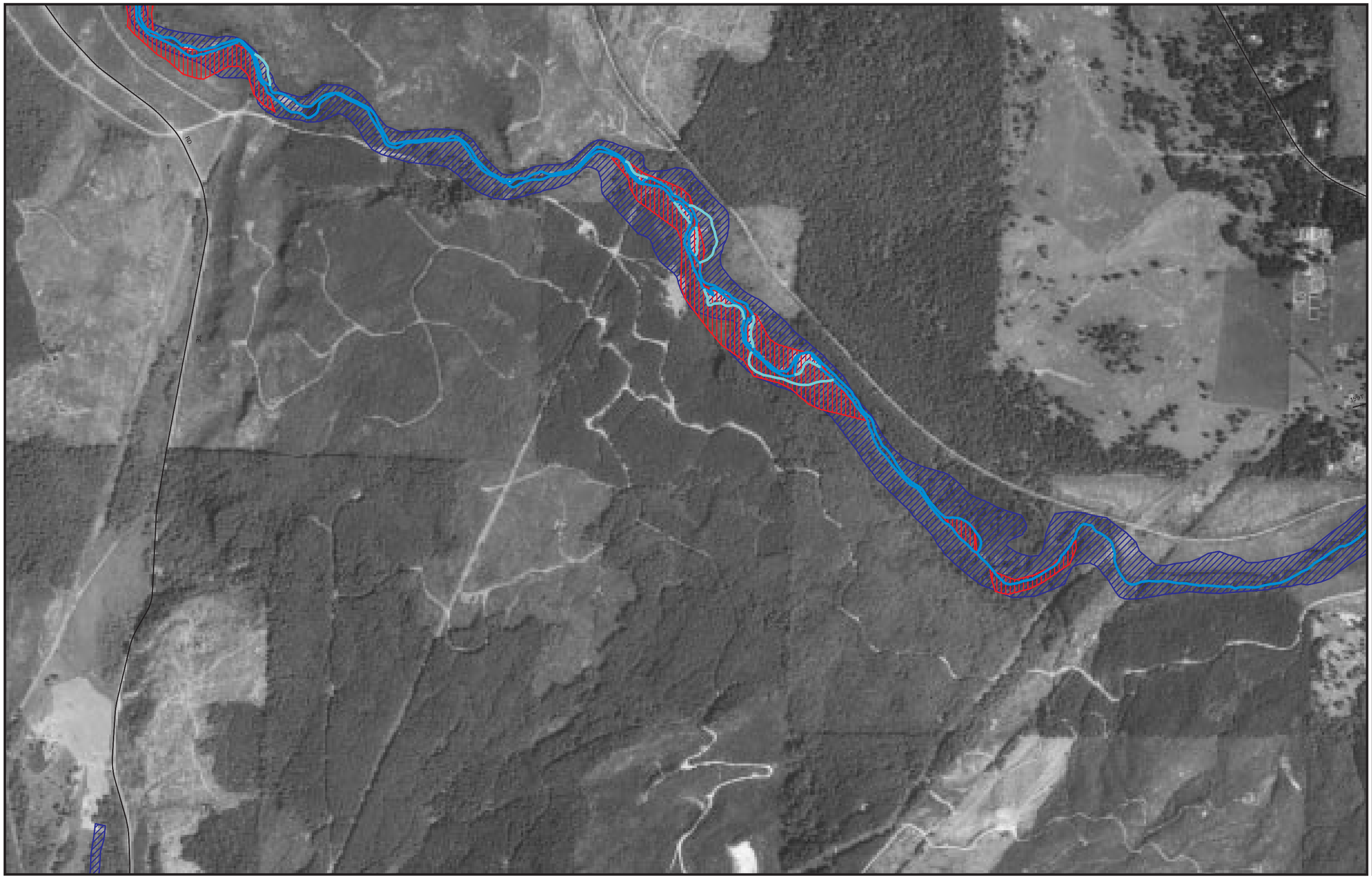
Deschutes River Off-Channel Habitat Inventory



Legend

- Mainstem and Tributaries
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Habitat Types

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Note: Overflow channels and wetlands were digitized from 1996 one- and three-foot ortho photos and represent a subset of existing features. Selection criteria are listed in: *The Deschutes River Off-Channel Habitat Inventory.*

Map Produced By:

Thurston Regional Planning Council

for

Squaxin Island Tribe
Natural Resources

Aerial photos flown in 1996

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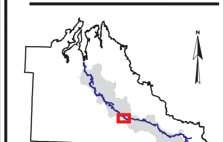
Location Map



Map 10 of 18

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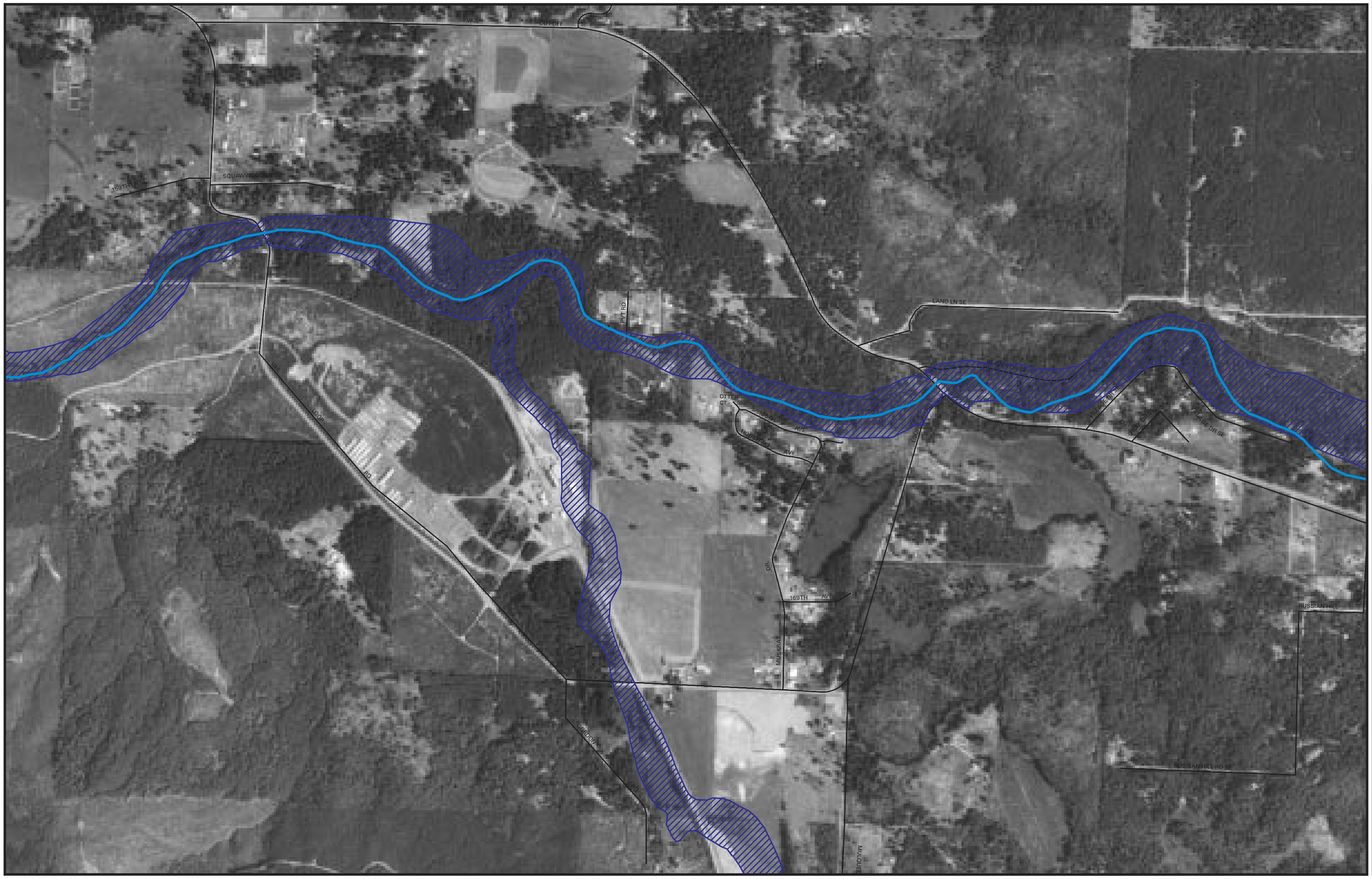
Deschutes River Off-Channel Habitat Inventory



Legend

Mainstem and Tributaries

Meander Zone

100-year Floodplain

Habitat Types

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Overflow Channels

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Map Produced By:

Thurston Regional Planning Council

for

Squaxin Island Tribe Natural Resources

Aerial photos flown in 1996

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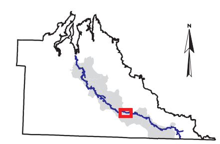
Location Map



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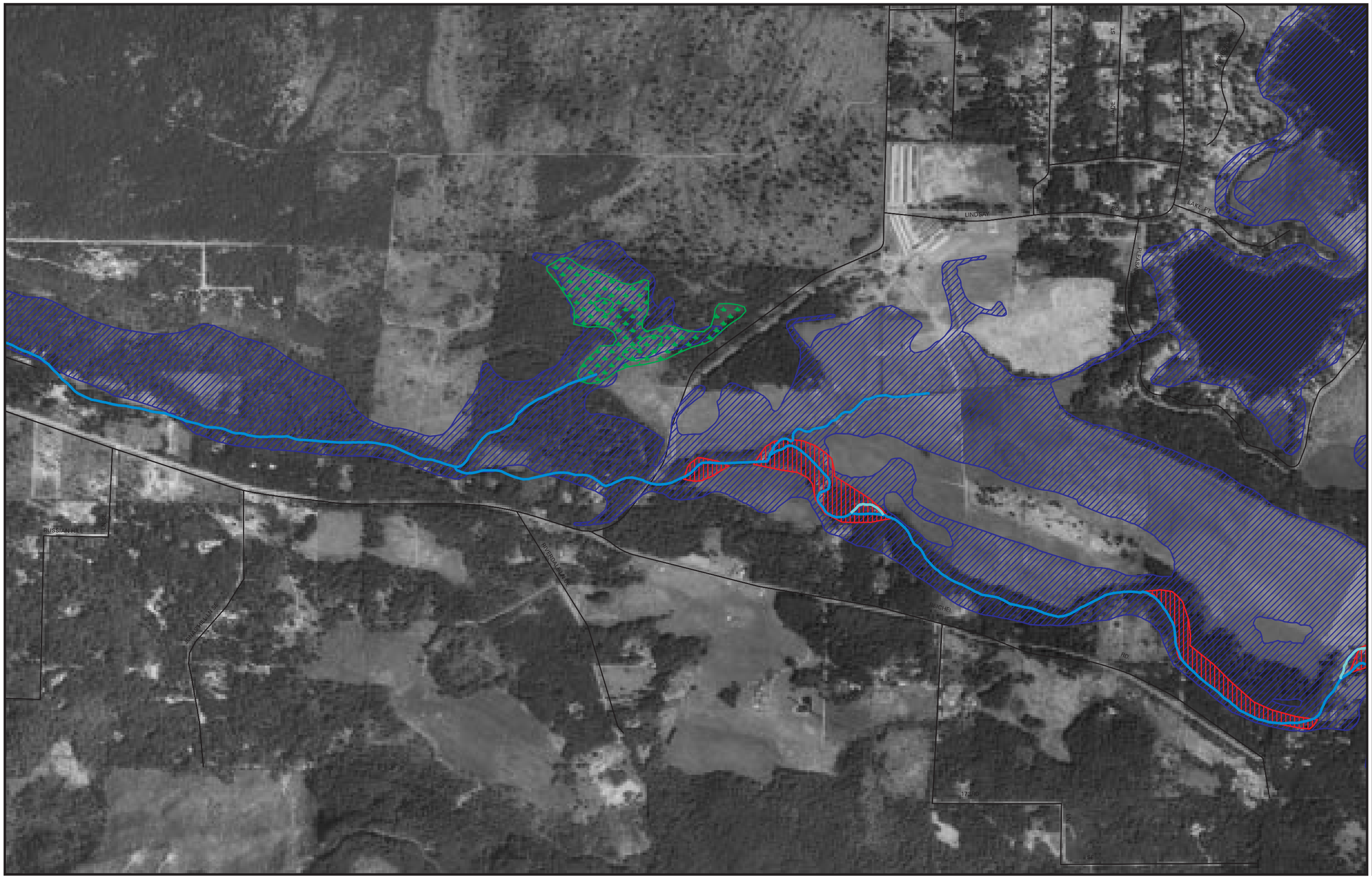
Deschutes River Off-Channel Habitat Inventory



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Thurston Regional Planning Council

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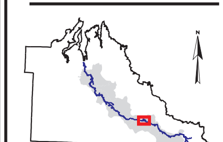
Location Map



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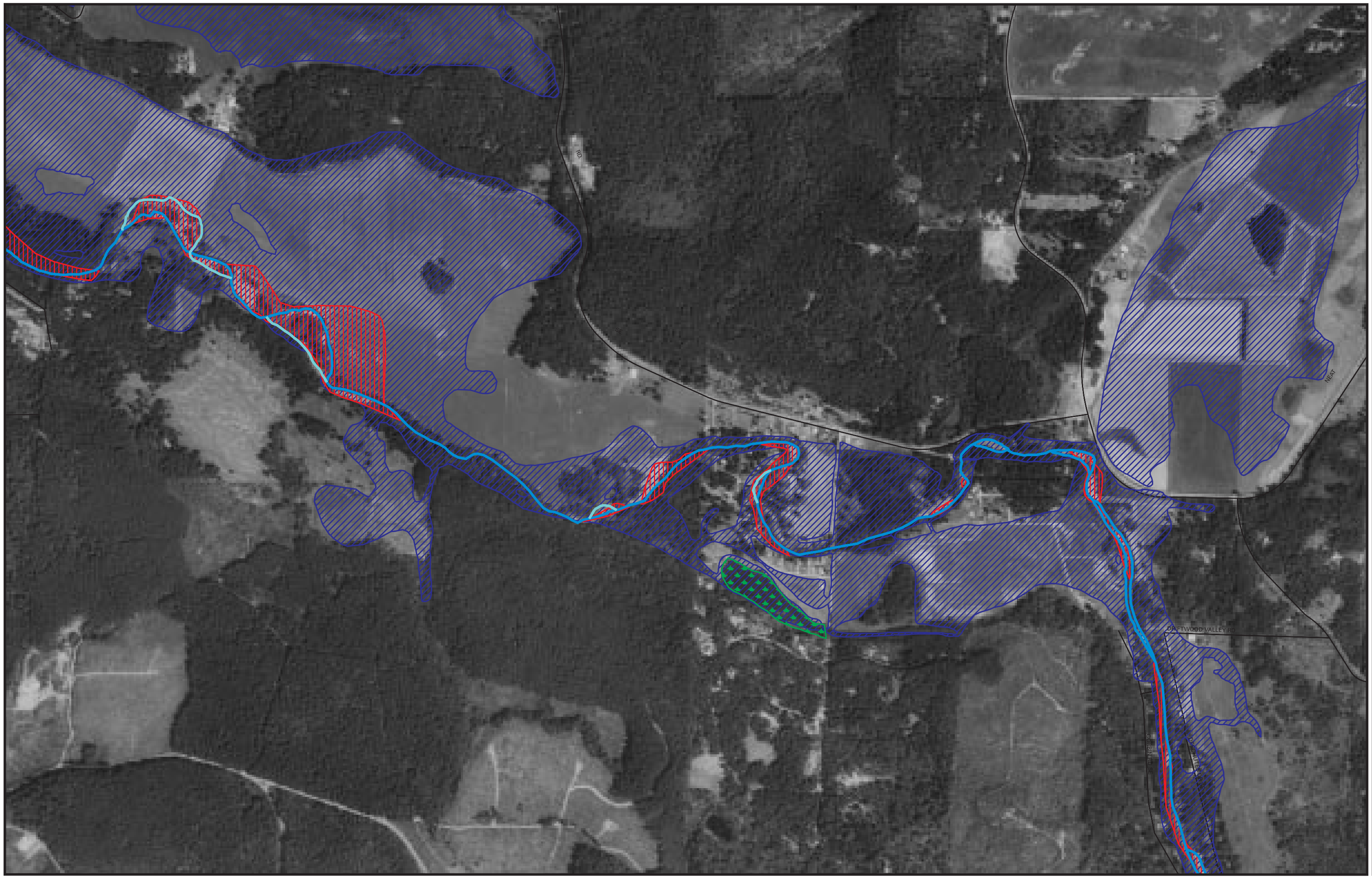
Deschutes River Off-Channel Habitat Inventory



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Thurston Regional Planning Council

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Squaxin Island Tribe Natural Resources

Aerial photos flown in 1996

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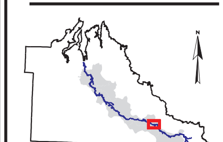
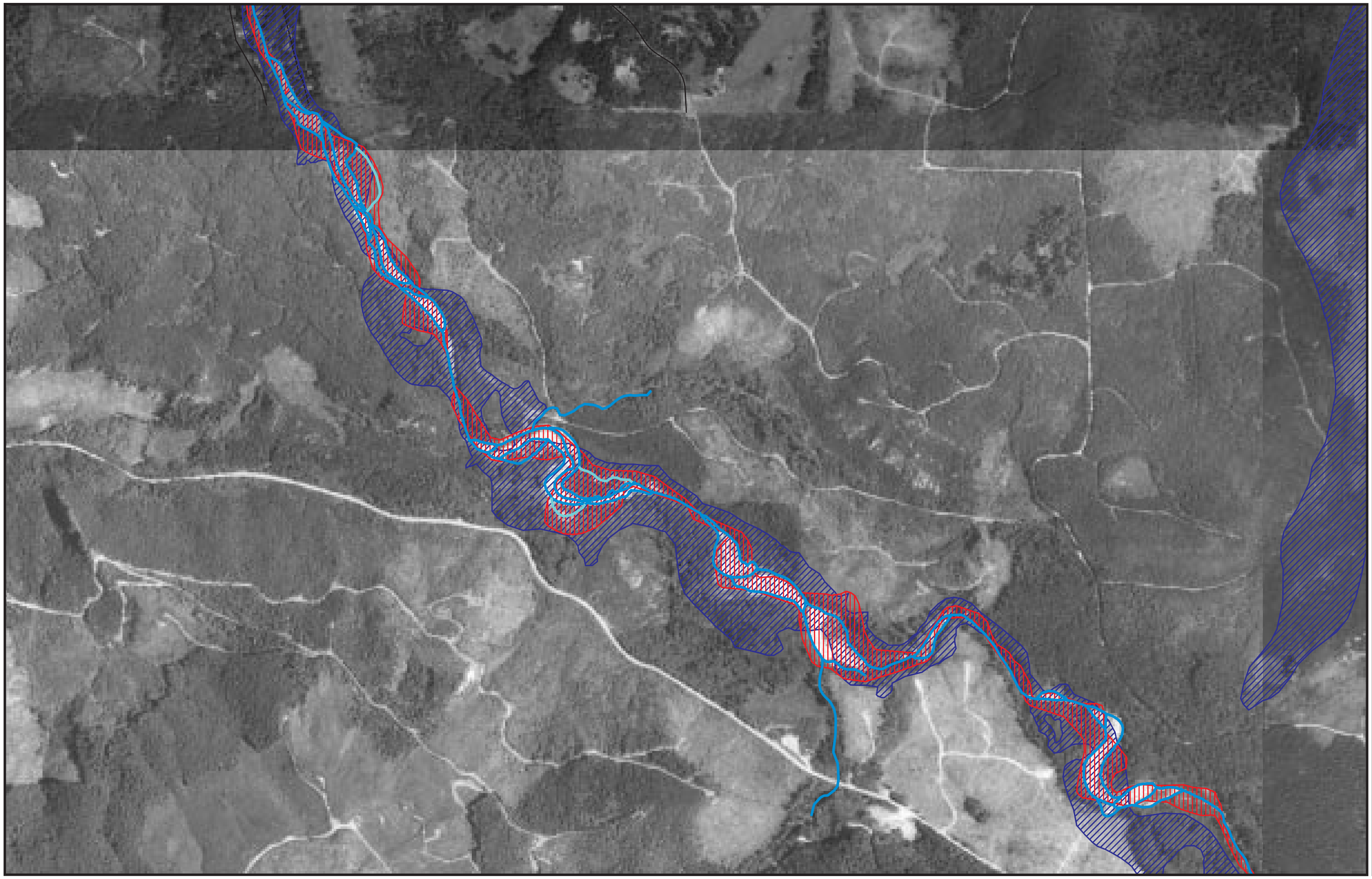
Location Map



Map 13 of 18

Deschutes River Off-Channel Habitat Inventory



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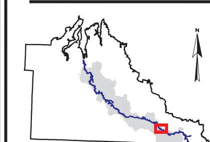
Location Map



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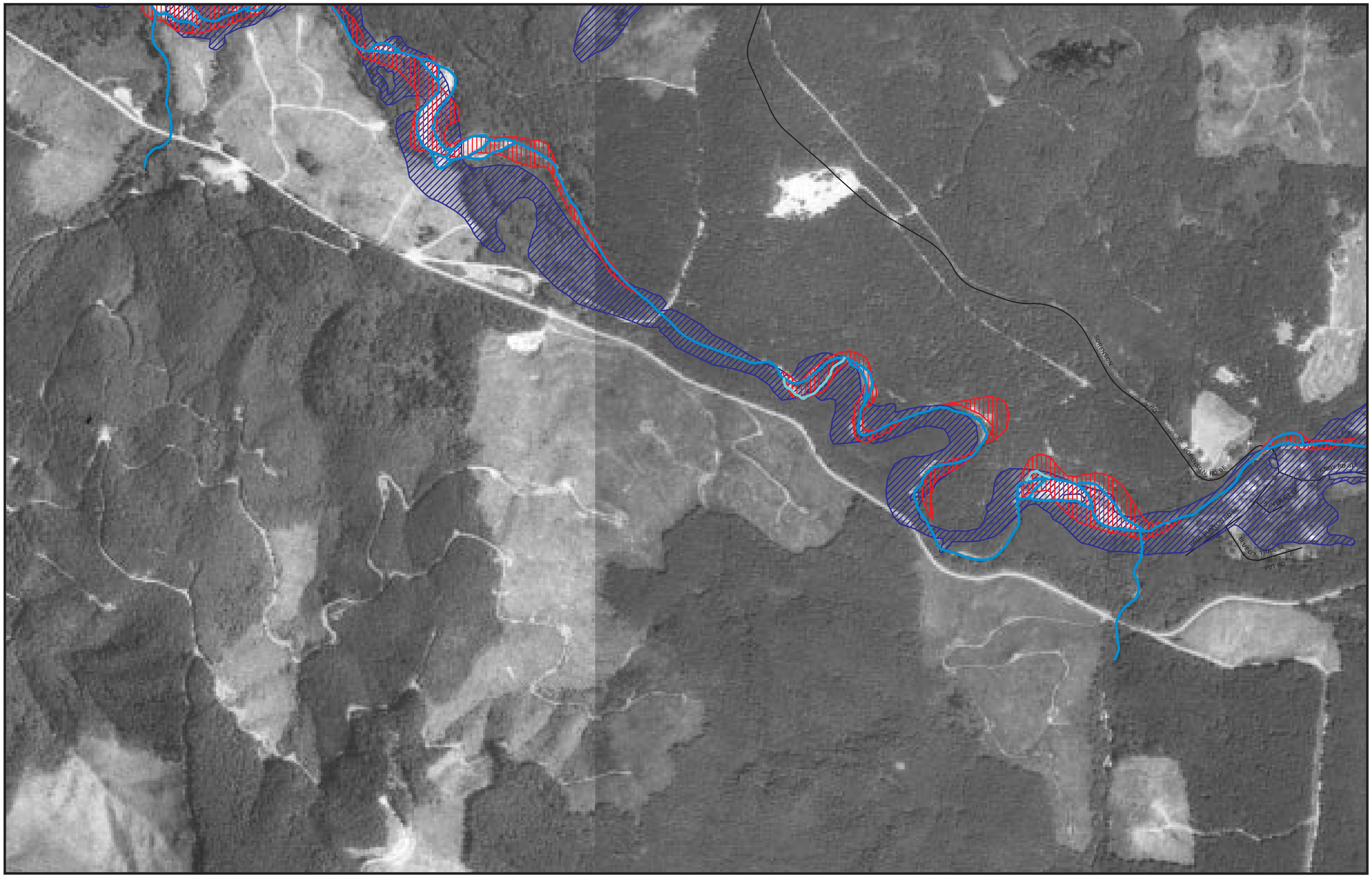
Deschutes River Off-Channel Habitat Inventory



Legend

Mainstem and Tributaries

Meander Zone

100-year Floodplain

Habitat Types

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Map Produced By:

Thurston Regional Planning Council

for

Squaxin Island Tribe Natural Resources

Aerial photos flown in 1996

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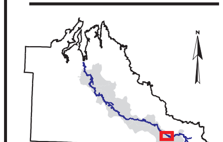
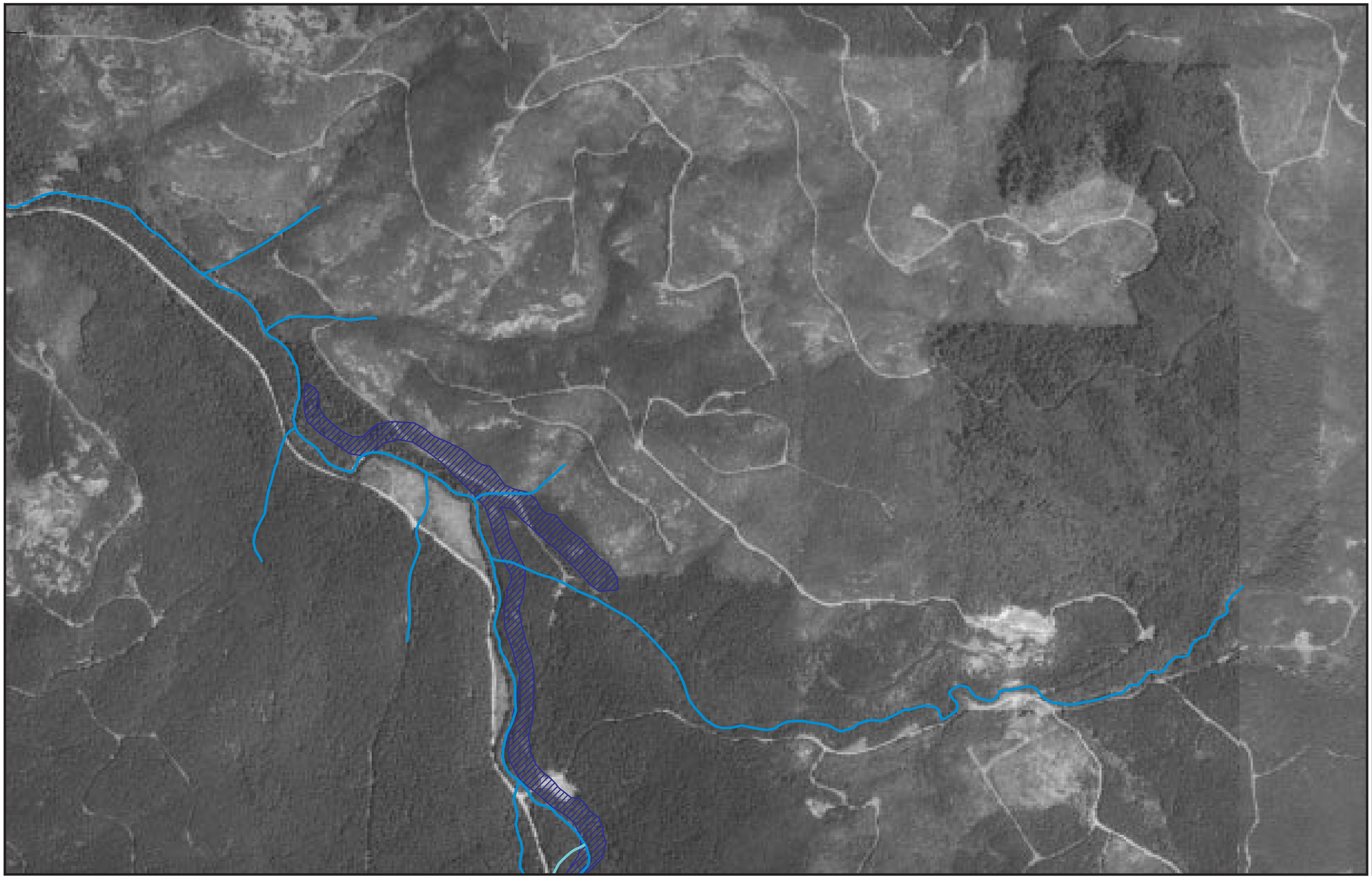
Location Map



Map 15 of 18

Deschutes River Off-Channel Habitat Inventory



Legend

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Thurston Regional Planning Council

for

Squaxin Island Tribe
Natural Resources

Aerial photos flown in 1996

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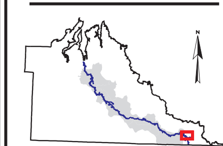
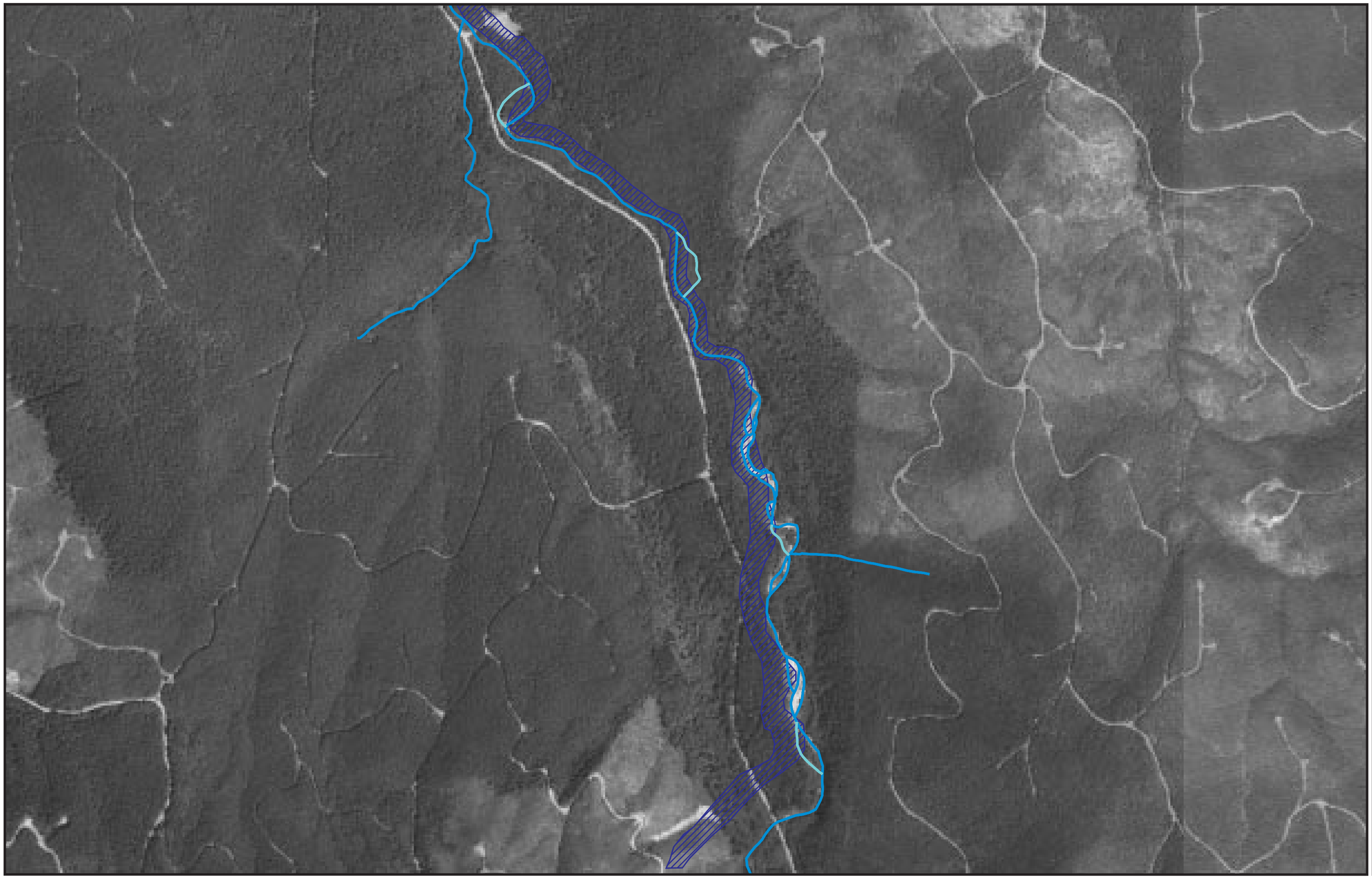
Location Map



Map 17 of 18

Deschutes River Off-Channel Habitat Inventory



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for

Squaxin Island Tribe
Natural Resources

Aerial photos flown in 1996

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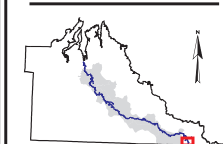
Location Map



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APPENDIX 3

This appendix includes a letter from Jeff Dickison (Squaxin Island Tribe) regarding the current status of Deschutes River coho salmon.

SQUAXIN ISLAND TRIBE

TO:	Interested Parties
FROM:	Jeff Dickison, Biologist
DATE:	June 11, 1999
RE:	Deschutes River Coho Salmon Stock Status

There has been much confusion in recent years regarding stock status for coho salmon on the Deschutes River system in southwestern Washington. The confusion exists primarily because of outdated information represented in a status review summary seven years ago. This memo will attempt to update the stock status based on more recent information.

The stock status in 1992 was projected as healthy based on returns through 1991, but with the qualifier that the stock was in a short-term severe decline and warranted further examination if the run size continued to track recent levels. Unfortunately, the run size continued to worsen reaching successive all time lows during the 90's. The run escapement has fallen below its goal since 1988 and the run size remains below its long term average.

Examination of the spawner/recruit function indicates a deterioration over the 90's. The relationship between female spawners and smolts generated has consistently fallen below the curve throughout the period. Productivity has been demonstrated to be falling in the system thus linking the declining run to habitat conditions.

Catastrophic habitat loss occurred as the result of a storm in January, 1990 which wiped out productive coho spawning areas in the upper system. Low water conditions during recent years have amplified the habitat impacts on coho production. Habitat factors are well understood to be a significant part of the decline of coho salmon in the system.

The Washington Department of Fish and Wildlife has reached the same conclusion as the Squaxin Island Tribe. In a 1996 memo Department staff proposed changing the stock classification to depressed for this river system. Though there has ben no formal effort to upgrade a state-wide stock status inventory, the two fish management interests both consider the Deschutes coho salmon stock status in the Deschutes River to be depressed.

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